Instruments

THE MAGAZINE OF

Measurement and Control

Vol. 18
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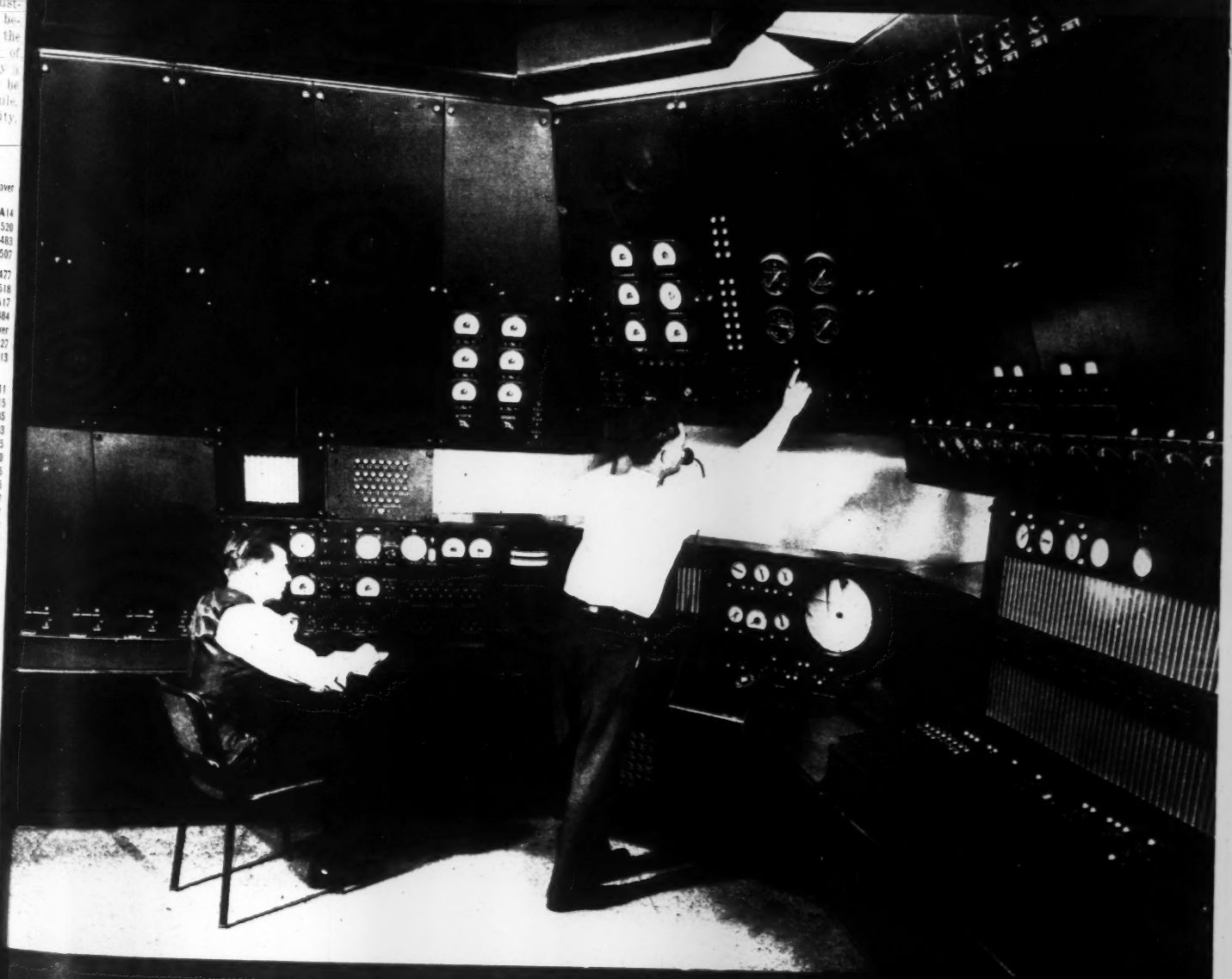
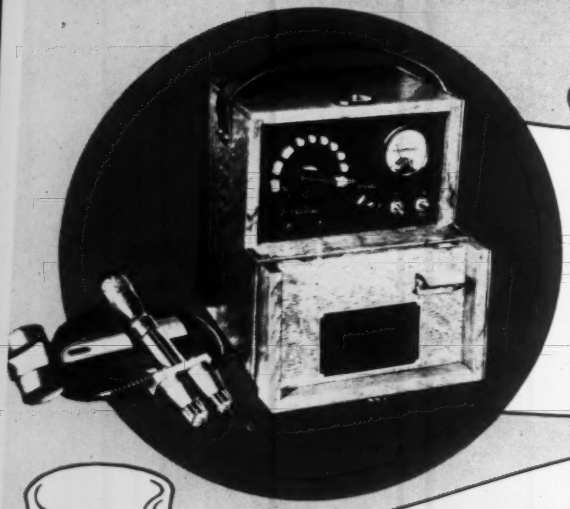
1945
No. 8



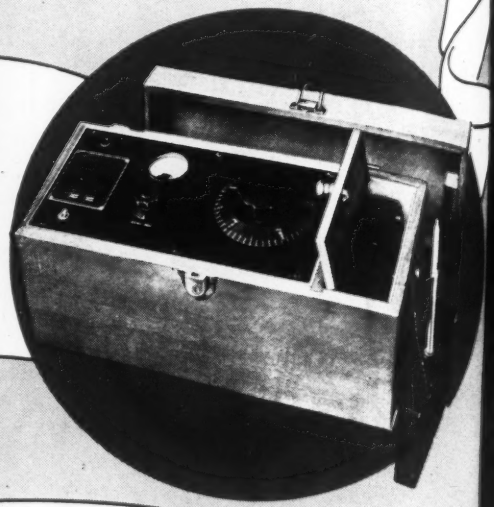
INCLUDING *Aviation Instruments*

TAG MOISTURE METERS SERVE MANY A PRODUCTIO FRONT TODAY . . . MORE AFTER VICTORY!



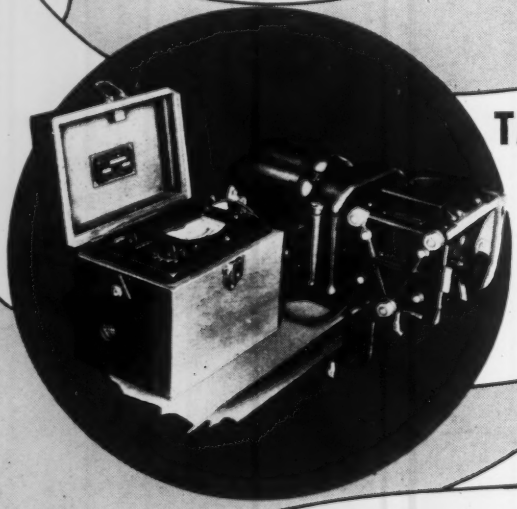
TAG MOISTURE METER FOR WOOD

The TAG-Heppenstall Moisture Meter for wood is recognized as the international standard in many lines of industry where wood plays a part. Due to a manufacturing tolerance of ±0.25%, this meter does its job efficiently on the plywoods, veneers and balsa wood so widely used in the construction of cargo planes, gliders and bombers . . . a practical, metal-conserving factor in the War program. This instrument has also proven helpful in measuring the moisture content of card and leather board.



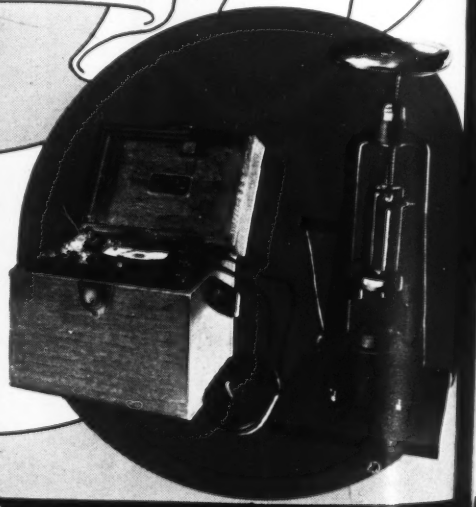
FOR POWDER & GRANULAR MATERIALS

TAG Moisture Meter—Dielectric Type. Many products, such as dehydrated foods, flour, plastic moulding material, Army rations and many other similar materials, which cannot be tested by the electrical conductance method can now be measured on the TAG Moisture Meter (Dielectric Type). By means of this instrument, a constant vigilance is maintained over Army rations so that they shall conform exactly to the strict specifications of the Quartermaster Corps. In addition, the Meter is serving by testing the moisture content of cehydrated foodstuffs, thus saving valuable space.



TAG MOISTURE METER FOR GRAIN

This TAG-Heppenstall Moisture Meter was calibrated in collaboration with the United States Department of Agriculture over five crop years for wheat, corn, rye, barley, oats and rice (rough and milled), sorghums, vetch and edible beans to a tolerance of ±0.05%. It helps keep the steady stream of sound foodstuffs flowing to our fighting forces and our allies.



TAG MOISTURE METER FOR TOBACCO

The TAG-Heppenstall Moisture Meter for determining the moisture content of tobacco, constantly guards the products of America's leading tobacco manufacturers which go to the home front and those allocated to the Armed Forces. This Meter has also made possible the discovery and development of many substitutes for products that the present War has made very scarce or impossible to obtain, i.e.—A substitute for manila fibre, a most valuable material for marine rope.

PORTABLE PRODUCTS CORPORATION

TAG

Instruments for Indicati Recording and Controllin

C.J. TAGLIABUE DIVISION . . .

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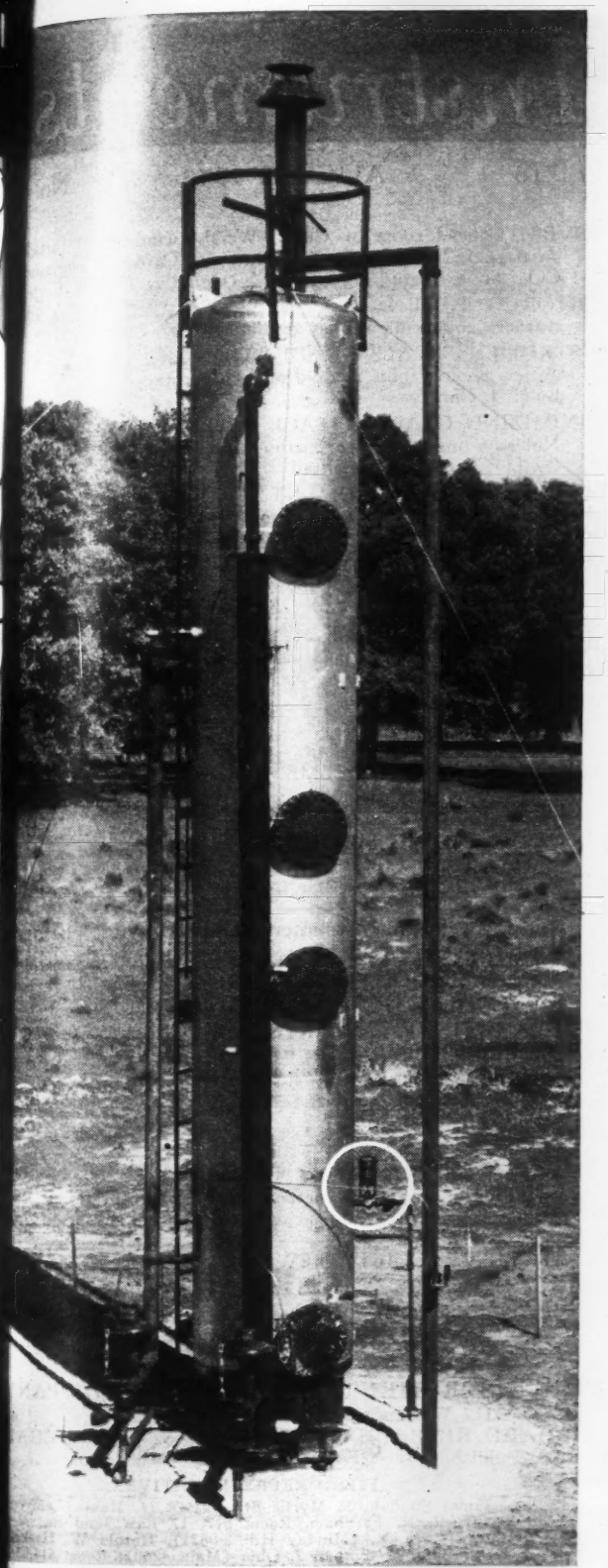
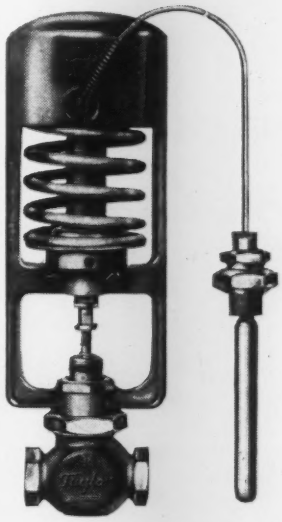


One of many thousands of National Tank Co.'s Automatic Emulsion Treaters on which Taylor Self-Acting Temperature Controllers are standard equipment.

UY ANOTHER WAR BOND TODAY!

Thousands of these "tough babies" are doing a man's job!



NO doubt about it, these Taylor Self-Acting Temperature Controllers *are* tough babies. And Automatic Emulsion Treaters in the oil fields are typical of the many industrial processes to which their dependable performance, simple operation and economy are ideally adapted.

Many thousands of these standard Taylor instruments are in service today throttling the fuel supply to these treaters, automatically maintaining the proper temperature for the most efficient removal of water from the oil-field emulsions with minimum loss of oil. This process, which has such an important bearing on the marketability of the crude, is handled to perfection by the Taylor Self-Acting Controller. It just doesn't require a more expensive, more complicated instrument.

You can spend a lot more money than necessary on fancy controls (and we make them, too) for many jobs where very close control is not required. Typical jobs which the Taylor Self-Acting Temperature Controllers take in stride are: condenser cooler water in stills, oil field superheaters, wax coating machines, plating and rinsing tanks, bottle and can washers, mixing and cooling kettles, hot water tanks, diesel water jackets, feed water systems, etc.

They require no auxiliary air supply for operation. Double seated valves are available in sizes up to 2″; single-seated composition disc types up to 1″. Numerous standard temperature ranges within limits of 10° and 340° F, and semi-standard ranges within limits of 165° and 610° F.

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Instruments

Vol. 18 AUGUST 1945 No. 8

COVER: Control room of Curtiss-Wright wind tunnel (article on page 537) is also "nerve center for Cardox low-pressure CO_2 fire-extinguishing system." (Courtesy Cardox Corp.)

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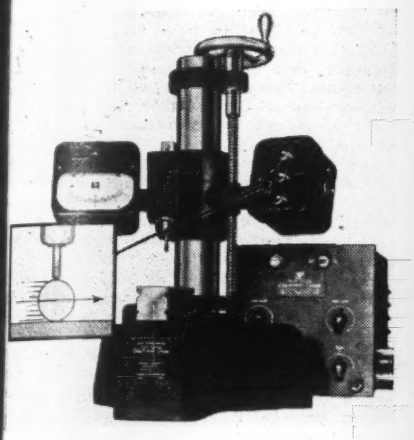
…" long. Units drilled for 6/32 screw clearance. 1½" tinned copper leads. Non-inductive. "Type …" similar to "RL" except max. res. 1 meg. and size ½" diam. × 15/16" long. Both resistors are furnished with standard tolerance of ½%. Tolerance to 1/10% at higher cost. These resistors are particularly applicable to test and portable equipment and apparatus because of their small dimensional size.—*Instrument Resistors Co., 25 … Unity St., Little Falls, N. J.*

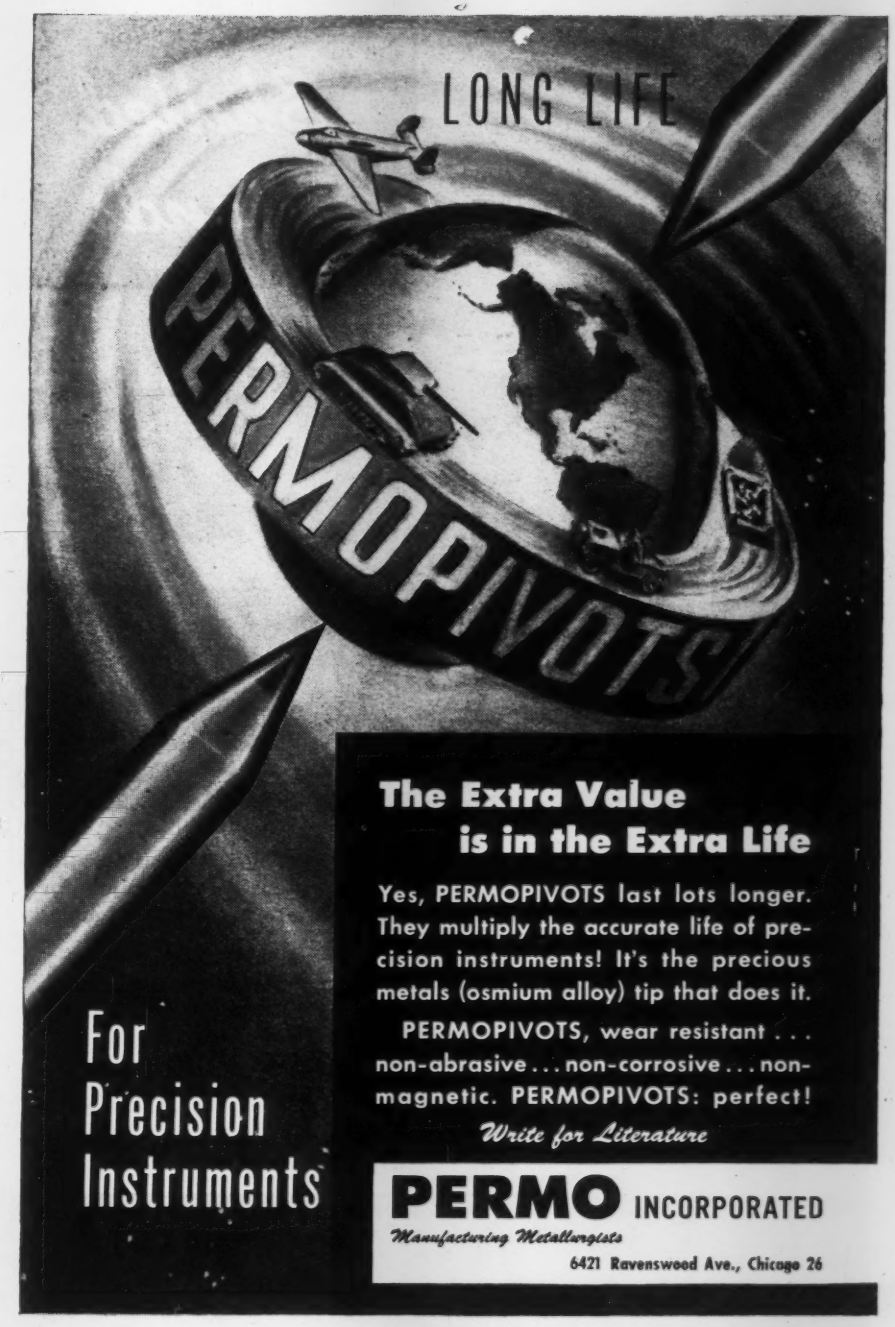
Electric Gaging System with Electronic Amplification

New "Federal Model 130 Electronic Gage" consists of a gage stand assembly and an amplifier or control unit. Base of gage stand is a heavy casting to which is clamped



gaging anvil and polished steel column, on which slides casting which supports Electric Gaging Head, Dial Indicator, and Limit Lights. Gaging head is clamped tightly to

column when measuring, is raised or lowered over a 6" range by a screw mechanism to approximate position (final adjustment described below). Three limit lights indicate under, within or above tolerance: green light signals OK; red, oversize; amber, undersize. Magnification is secured by a series of electronic tubes in an amplifying circuit, whose output operates the Dial Indicator, so that magnification is secured without the use of gears, rack or other strictly mechanical devices. Use of electronic circuit is claimed to reduce inaccuracy to a minimum. "Model 130" has four magnifications, which allow readings from ten microinches to 0.003". When range switch is set to greatest magnification (approximately 14,000), a 0.0002" movement of gage head spindle produces full-scale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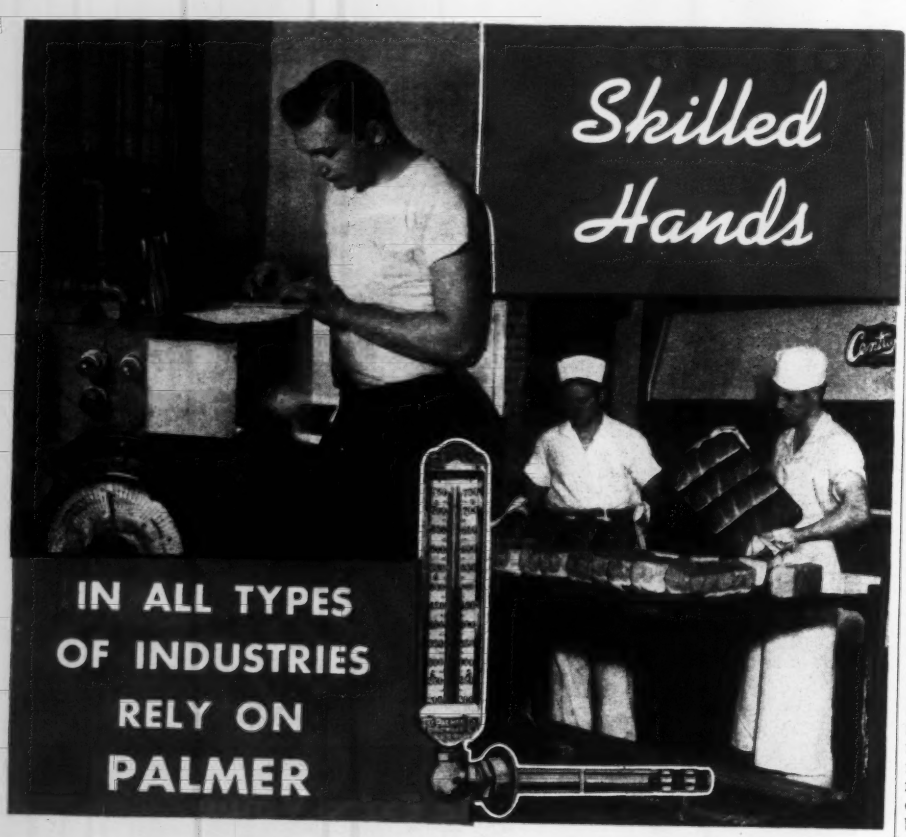

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reading on dial indicator. Other settings produce full-scale readings with spindle movements of 0.0006", 0.002" and 0.006" and corresponding magnifications of 4650, 1400 and 465. Another control on the front panel, for zero adjustment, is used to set dial indicator accurately after gage head has been roughly positioned above workpiece by the screw adjustment. This final setting is accomplished electrically, instead of by a find physical positioning of the gage head, so that accurate settings of the gage may be readily made, even on the most sensitive range. The limit light controls make it possible to set the limit lights so that they will indicate any tolerance within range of instrument from + 0.0001" to — 0.003". *Operation:* In the gage head itself are two fixed coils and one movable coil. Movable coil is mounted on gage spindle and moves with it. Fixed coils are energized by a low-frequency oscillator, and so arranged that zero current is induced in the movable coil when it is electrically centered between them. As movable coil moves away from this electrical center towards either field coil, current induced in it increases in direct proportion to distance from electrical center. In this way distance values are transformed directly into electrical values. "Model 130" operates from a single-phase 115-volt 60-cycle supply. Minimum power requirements is 70 watts. If d.c. only is available, a converter with minimum output of 70 watts is required. Current in movable coil is fed to a voltage-dividing network, controlled by the range switch. No voltage division takes place at the highest magnification of range switch. As range switch is moved to lower magnification, positions, voltage division increases proportionally. Output of voltage-dividing network is greatly magnified by a stabilized amplifier. Amplifier houses all of components of the electronic circuits, and on its front panel are the controls used in setting up the Gage. Specially-designed circuits compensate for line voltage variations and changes in amplifier components. Amplifier is equipped with staple components, operated well below their ratings, which insures long life and low-temperature operation. Amplified r-f. current is rectified by a detector circuit which converts the current into pulsating direct current, which actuates a milliammeter. Deflection of milliammeter needle is proportional to movement of spindle. Direct current from the detector, to a voltage in proportion to spindle movement, actuates the grids of the limit light control tubes, and is also used to control sorting or indicating auxiliary equipment. Detector circuit is also used as a phase discriminator: Dial Indicator has no phase discrimination, and with an ordinary detector circuit any given reading could be produced by two positions of gage spindle. To eliminate this confusion a special circuit makes detector sensitive to current of a given phase and completely insensitive to current whose phase is displaced by 180°. Dial Indicator thus records movement of field coil on the one side of electrical center only. Magnification for all ranges may be reset by switching to lowest magnification and using (as standards) gage blocks whose size difference is sufficient to produce a full-scale deflection of Indicator. Full-scale Dial Indicator reading may be made to equal size difference of blocks by adjusting magnification control (which is made available by removing snap button from side of amplifier). This control adjusts gain of amplifier, which remains constant for all ranges of magnification. Total error in the gage blocks used to set the lowest magnification range will be a small percentage of the full-scale on that range, and the resulting error in amplifier gain will be of equal value. Gain being constant, error will be constant at all ranges, and a 1% error in setting at low magnification will produce an error of 1% at highest magnification, or two millionths of an inch in a full-scale reading. *Limit Controls* on front of amplifier panel adjust bias of control tubes so that they may be set to energize relays for any specific grid voltage proportional to spindle movement; and as these relays control the limit lights, they may be set to indicate any desired spindle movement. Limit lights are set by placing a nominal block under spindle and setting zero adjustment control so that Dial Indicator reads extreme minus value of tolerance; and upper limit when Dial Indicator reads extreme plus tolerance. — *Federal Products Corp., 1144 Eddy St., Providence 1, R. I.*

Limits Bridge for Sorting Resistors

New "Model 81" Low-range Limits Bridge, one of a series of units for rapid comparison of large quantities of resistors having comparable values, is adapted to

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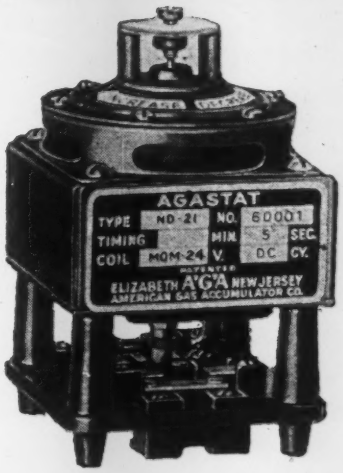

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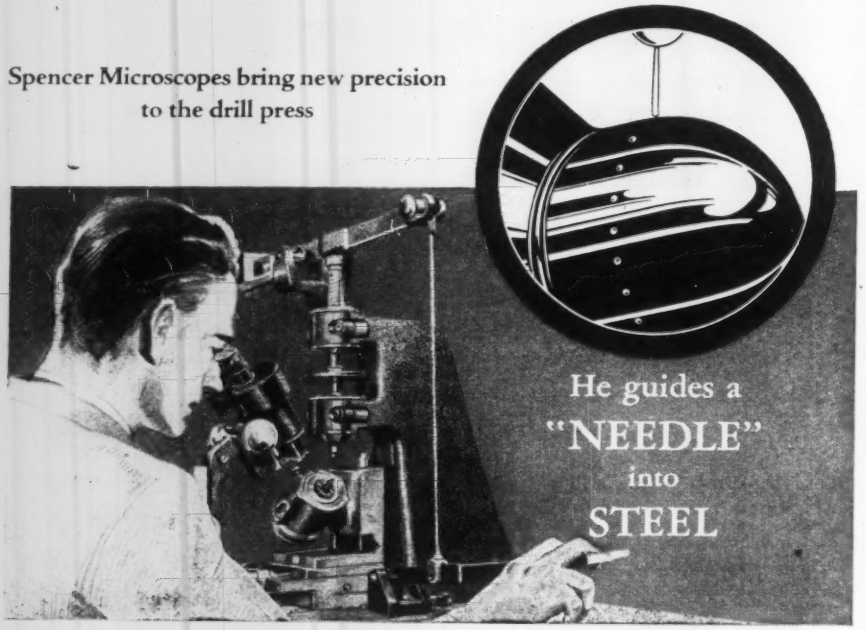

With miniature drills as small as .0065" in diameter, the operator produces Diesel engine inspection nozzles with openings barely visible to the naked eye, yet held to remarkably close tolerances.

To meet the need for such precise drilling, National Jet Company manufactures these small drills and is now supplying a precision drill press equipped with a Spencer Stereoscopic Microscope through which the operation can be observed.

To other manufacturers whose plans call for optical parts or complete instruments, we offer extensive research and manufacturing facilities, plus many years of experience in building fine Spencer scientific instruments.

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COMPANY
Scientific Instrument Division
Buffalo 11, New York

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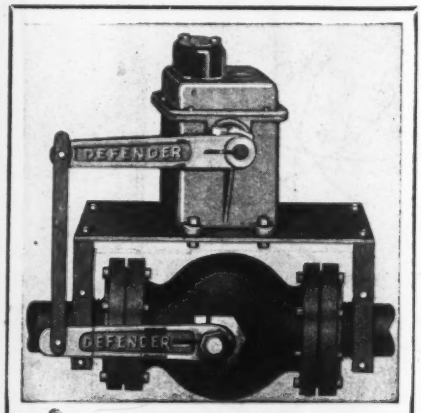

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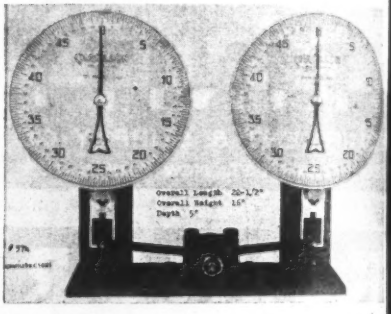
volume testing of resistance values up to 2,000 pieces an hour — motor windings, transformer primaries or secondaries, rheostats, potentiometers, lamp shunts or multiplier resistors, etc. Extreme flexibility is attained through use of an external reference standard. A combination test fixture and automatic control switch adds to this characteristic; also binding posts at right side of unit for connection to user's test fixture where desired. Left-hand binding posts are for connection of reference standard which can be supplied if desired. "Model 81 Limits Bridge" is battery-operated. Overall adjustable range is from $\frac{1}{4}$ ohm to 10,000 ohms, with adjustable ratio arm, sensitivity control, production type test fixture with automatic on-off switch. Sensitivity control range is from $\pm\frac{1}{4}\%$ to $\pm 10\%$. Indicator is a sensitive zero-center galvanometer. Unit is self-contained, measures 8" × 8" × 12", weighs 18 lbs., mounted in attractive grey wrinkle finished metal cabinet. On sloping panel are mounted ratio arm control, galvanometer, binding posts and combination test fixture.—*Associated Research, Inc., 231 S. Green Street, Chicago 7, Illinois.*

Torque Testers

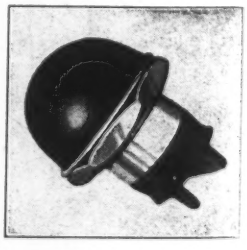
New torque testers are for quick, accurate determination of torque and force. Applications include checking torque wrenches, measuring torque necessary to screw and



unscrew threaded parts, determining starting torque of motors, testing elastic couplings, etc. New instruments make it possible for unskilled workers to make torque adjustments that otherwise would require a highly-developed sense of touch, acquired only after years of experience. New Torque Testers are made in a range of capacities from 50 inch-ounces graduated in $\frac{1}{4}$ inch-ounces, to 1000 foot-pounds graduated in $\frac{1}{2}$ foot-pounds. To use, it is merely necessary to apply torque to the shaft and to read the resulting force directly on the dial. Shaft can be provided with pin, vise, adapters, or other fittings to suit the application.—*John Chatillon & Sons, 85 Cliff St., New York 7, N. Y.*

Snap Switch

New "Junior" snap switch, rated at 15 amperes - 110 volts a.c., is only 9/16"



diameter and 31/32" long overall. It is complete in itself but can also be furnished with special over-travel adapters and special mounting sockets. A pressure of 4 lbs. is required to operate "Junior." New small switch can be furnished normally-open, normally-closed, two-circuits or single pole dou-

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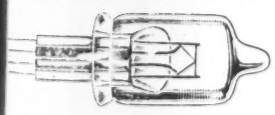

Full Size

FIELD thermocouples meet the most rigid specifications of prominent instrument makers.

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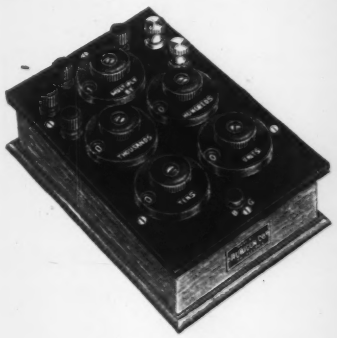

Rubicon Wheatstone and Kelvin Bridges are available in a number of types to suit various applications. All are made in accordance with the highest traditions of the instrument maker's art and are fully guaranteed.

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★ **Troubled by fluctuating line voltage? Just include a Clarostat Automatic Line Voltage Regulator in your assembly—or as an accessory plugged in between connecting cord and outlet. At 110 volts the resistance is low. Voltage drop is negligible. But as line voltage increases, the resistance builds up so as to maintain uniform and safe voltage to your assembly.**

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If it has to do with resistors, controls or resistance devices, send it to us for engineering collaboration.

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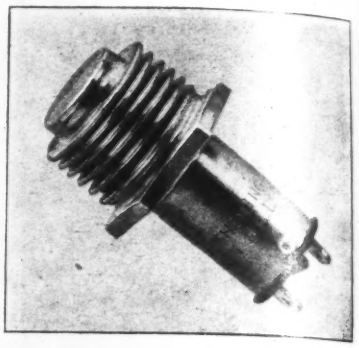
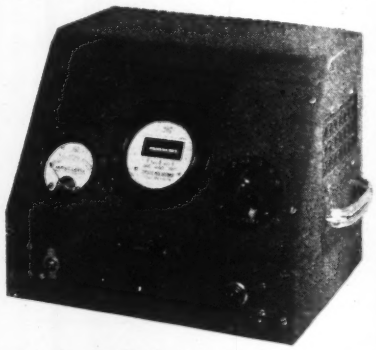


ble-throw. It is supplied with nut and lockwasher—mounting thread is ½"—32. Where it is screwed into an over-travel adapter thread of adapter is also ½"—32 although other threads can be supplied where necessary. Load ratings are based on tungsten filament test.—*Robert Hetherington & Son, Inc., Sharon Hill, Pa.*

Vacuum-tube Frequency Meter

New "Model 39-VTF" vacuum-tube frequency meter is designed to provide maximum degree of accuracy in measuring frequencies located within certain definite



bands. A multivibrator circuit in the electronic unit divides the incoming frequency by 2, 3, 4, 6 or 9. The resulting frequency is measured by a standard vibrating-reed frequency meter. This combination will measure frequencies in the 400, 800, 1200, 1600, 2400 and 3600 cycle bands with an accuracy of 0.25% or better independent of line voltage. Accuracy is said to be permanently inbuilt at the factory so that no subsequent calibration or standardization is required at any time. No initial stabilization period is required, and no protection is needed against accidental frequencies above the range being measured. Characteristics of "Model 39-VTF, Series A": (1) Frequency Ranges: Basic range 380-420 cycles. Multiplier switch permits use in ranges of 2, 3, 4, 6, and 9 times the fundamental range. (2) Accuracy of ±0.25%, regardless of voltage, is easily obtained. Harmonic content of unknown frequency must not exceed 10-15%. (3) Input sensitivity: 500,000 ohms. (4) Voltage range: 100-350 volts. (5) Power consumption: Approximately 25 watts at 115 volts, 60 cycles. (6) Cabinet size 8"×10"×8". (7) Tubes: 2-6N7 multivibrators, 1-6N7 input, 1-6J5 buffer, 1-6V6 amplifier, and 1-6X5 rectifier. It should be noted that this instrument measures frequencies in six bands. Makers emphasize that they are not able to furnish an instrument which will measure a range from 400 to 3600 cycles in one continuous band.—*Jackson Instruments, Inc., 441 Chapel St., New Haven 8, Conn.*

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New adaption of "Super Sight" magnifier with fluorescent lighting is magnifying lens and fluorescent light assembly mounted on a perfectly balanced bracket that can be ad-

A precision resistor designed especially for the requirements of the laboratory and fine instrumentation. A new standard of stability in a range where instability has been prevalent.

Supplied only in values from 1 megohm to 1,000,000 megohms.

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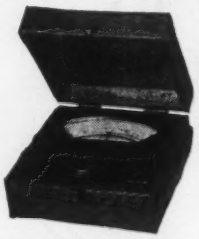

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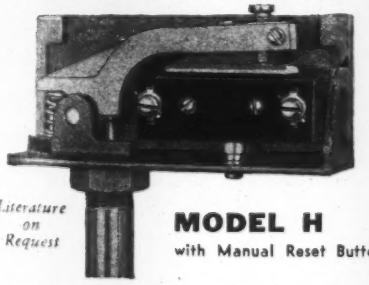

Literature on Request

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with Manual Reset Button

Available with switch normally closed for cutting off heat, stopping fan, closing valve —with switch normally open for lighting lamp or ringing bell—with single pole double throw switch . . . breaks heating circuit while closing alarm circuit. Sturdy, fool-proof reset button operates from outside case. Range 0-1400° F; adjustable range 200-300° F. Dimensions: 5⅛" x 1¾" x 3". Dial Pointer for easy setting.

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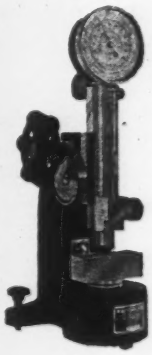

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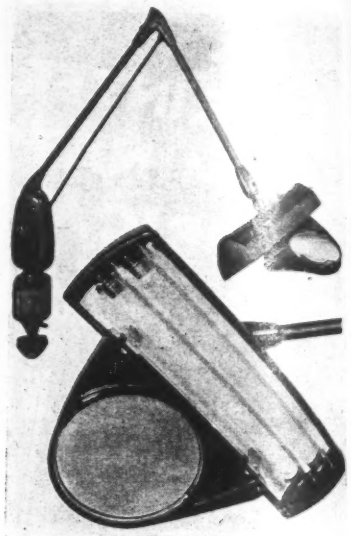

stantly placed in any position over a wid work area. Cool fluorescent lighting add substantially to comfort of operator. "Supe Sight" is now supplied in three types o lighting: (1) Standard bayonet type bulbs; (2) Lamps that are sealed to relie explosion hazard; (3) Fluorescent Lamps It is also supplied with three types brackets and two sizes of lenses, thus meet ing almost any industrial need.—*The Boye Campbell Co., (Safety Division) 6540 St Antoine St., Detroit 2, Mich.*

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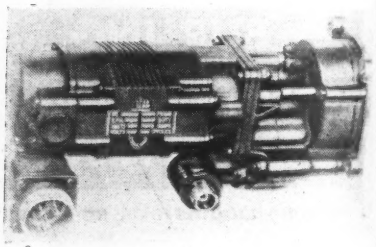
New "Series 206B Rotary Actuator" ha been designed for special flap installation to assure quick and safe pull-outs fro dives made at speeds at which moder



fighting planes now operate. Performanc of planes such as Republic P-47, and other show that engineers have met this cha lenge by building compressibility dive fla installations permitting quick pull-outs, high Maoh numbers, while plane is still a high altitude. Extreme diving momentu which ordinarily results when compressibi ity shock occurs on wing is offset by div flap action. Illustration shows "actuator for P-47 dive flap. This installation con sists of two "actuators" connected to th flaps by means of levers and rods, Lea flexible shafting, Lear angle drives, Lea bulkhead connectors, limit switches to con trol extent of travel of dive flap, a relay and a circuit protector, connected wit switch in cockpit. The two "actuators" ar interconnected by flexible shafting, through angle drives and couplings. This interconnection provides synchronization and for emergency power so that in case one motor is damaged by gunfire the other can drive both flaps. "Series 206B Rotary Actuator" is designed for heavy-duty loads up to 650 lb.-inches, with a normal load of 250 lb.-inches. It operates at 26 r.p.m. It is powered with the "D frame Lear Motor." "Lear Fastop" clutch assures accurate positioning. Complete power unit weighs less than 8 lbs.—*Lear Avia, Inc., Piqua, Ohio.*

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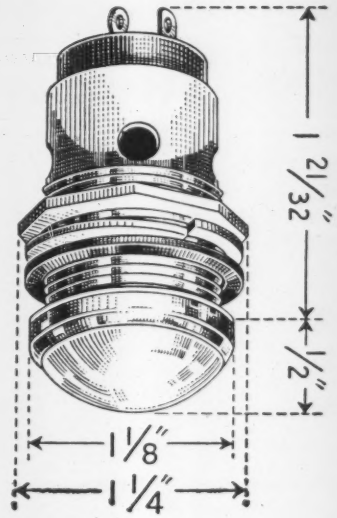

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HERE'S a heavy duty miniature base assembly designed for use on rugged equipment. Socket assembly and mounting tube are of one piece . . . so durably built they never need replacement. Solder terminals eliminate danger of connections becoming loose through vibration as with screw terminals. Mounts in 1" hole on panels up to ½" thick. Regularly supplied with colorless, smooth glass jewel frosted on back. Your choice of colored disc placed behind jewel offers advantage of glass appearing white until lamp is lighted. #276 is only one of a big line of better Drake Socket and Jewel Light Assemblies . . . standard or special types. Do you have our catalog?

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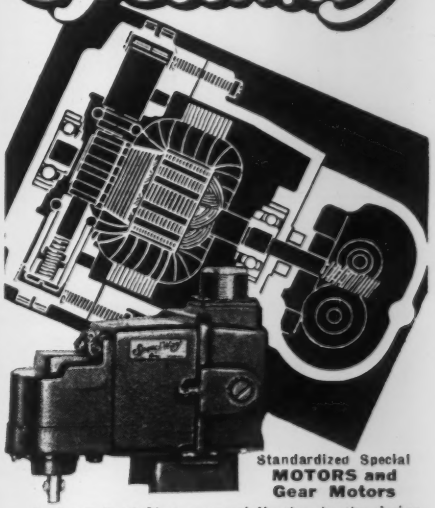

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INSTRUMENT SOCIETIES CALENDAR

City, Society and Secretary			Date	Place	Subject	Speaker
Atlanta, Georgia	Georgia Society for Measurement & Control	Robert E. Geminert, P.O. Box 1714, Atlanta		Blue Flame Room, Atlanta Gas Light Co.		
Baltimore Maryland	Baltimore Industrial Instrumentation Society	F. Ragan, Fuel Div., Beth Steel, Sparrows Pt., Md.		Engineers Club, 6 W. Fayette St., Balto.		
Charleston, W. Va.	Charleston Instrument Society	M. B. Lorig, 1506 Virginia St., Charleston 1				
Chicago, Illinois	Chicago Section, I. S. A.	A. J. Butler, c/o IHC, 2626 W. 31st Blvd., Chicago		M&M Club, 237 Merchandise Mart		
Cleveland, Ohio	Cleveland Instrumentation Society	A. J. McCullough, Minneapolis-Honeywell, 5005 Euclid Ave., Cleveland 3		Cleveland Engineering Society		
Detroit, Mich.	Instrument Society of Detroit	Cliff Sackett, Chrysler Eng'g 12800 Oakland Ave. Det't				
Florence, Alabama	Muscle Shoals Instrument Society	J. W. Moffett, 323 E. Mobile St., Florence				
Fort Worth, Texas	Fort Worth Electronics Club	Ralph Ely, 1116 E. Arlington, Fort Worth		Texas Hotel, Fort Worth		
Gulf Coast (Texas)	Gulf Coast Section, I. S. A.	C. D. Holt, 2509 Lake Shore Dr., Port Arthur, Texas				
Hartford, Conn.	Hartford Society for Measurement & Control	Gustave L. Manke, c/o Veeder-Root, Sargent & Garden Sts.		Bond Hotel		
Kansas City, Missouri	KC Industrial Instrumentation Society	Gordon H. Burke, 1527 Broadway, Kansas City, Mo.		Bluebird Cafeteria		
Los Angeles, Calif.	California Instrument Society	M. D. Pugh, 541 South Spring St., Los Angeles, Calif.		Melody Lane, Los Angeles		
Newark, N. J.	Society for Measurement & Control (New Jersey)	H. L. Close, 831 Dixie Lane, Plainfield, N. J.	Oct. 2	Essex House	Air-operated control and applications	E. R. Huckman
New York, N. Y.	New York Society for Measurement & Control	H. L. Hildenbrand, 206-07 33d Ave., Bayside, L.I., N.Y.	Sept. 24	Columbia U. Men's Faculty Club, 400 W. 117th St.	(To be announced)	
N. Indiana	Northern Indiana Section, I. S. A.	K. M. Frame, 25 Ruth St. Hammond, Indiana	Sept. 17(C) Oct. 19(C)	Ultramodern Dining Rm. 4607 Indplis Bld., E. Chi. Lake Hotel, 740 Washington St., Gary	Basic Principles of Indust'l Electronics Pneumatic Null Balance Applied to Ind'l Instr's	A. G. Mohaupt, DeForest's Training, Inc. C. B. Moore, Pres., Moore Products
Philadelphia, Pa.	Philadelphia Society for Instrumentation	G. E. Gress, c/o ATC, 34 E. Logan St., Philadelphia	Sept. 19(B)	Engineers Club, 1317 Spruce St.	(To be announced)	T. F. Robertson, Corning Glass Works
Pittsburgh, Pa.	American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St.	Sept. 24(B)	Roosevelt Hotel	Electronic instruments for process control	D. M. Nielsen, The Foxboro Co.
St. Louis, Mo.	St. Louis Society for Instrumentation	Gus Holubeck, Union Electric Co., Venice, Ill.				
Kingsport, Tenn.	Tennessee Section, I. S. A.	C. F. Palmer, 2924 J. C. Hwy., Kingsport	Sept. 10		(To be announced)	
Toronto, Ontario	Canadian Society for Measurement & Control	T. C. Agnew, Minneapolis-Honeywell Reg. Co.		Diana Sweets, 188 Bloor St. W., Toronto		
Washington, D. C.	Instrument Society of Washington	W. A. Wildhack, National Bureau of Standards, Wash'n		Interior Dep't Auditorium		
Whiting, Indiana	Whiting Instrument Men's Guild	Lloyd Clouse, 7344 Dante Ave., Chicago 19, Illinois				
Wyandotte, Mich.	Instrument Society of Wayne County	Wilson Fox, 33 Chestnut St., Wyandotte, Mich.				

(A) Meeting at 7:30, no dinner (B) Dinner at 6:30, meeting at 8 (C) Dinner at 7, meeting at 8 (D) Meeting at 8, no dinner

INSTRUMENT SOCIETY of AMERICA

President *pro tem:* Albert F. Sperry, 225 N. Michigan Ave., Chicago, Ill.

Vice President *pro tem:* Professor Carl Kayan, Columbia University, New York City.

Treasurer *pro tem:* Clarke E. Fry, 2331 Meadow Drive, Pittsburgh 21, Penna.

Secretary *pro tem:* Richard Rimbach, 1117 Wolfendale St., Pittsburgh 12, Penna.

For Committees see May issue of *Instruments*, pages 296-297.

CLEVELAND

At the first meeting of the 1945 officers of the Cleveland Instrument Society, the following committee members were selected:

Program Committee—John Brown (Standard Oil Company of Ohio) *Chairman;* Samuel Bousky (Jack & Heintz); Warren Stubblefield (Republic Steel); Robert Tozier (National Advisory Committee for Aeronautics).

Membership Committee — Walter Buhl (Jack & Heintz) *Chairman;* J. L. Kelley (Brown Instrument Co.); Harvey Lee (Foxboro Co.); S. G. Flack (Leeds & Northrup).

Publicity Committee — O. W. Heyman (Meriam Instrument Co.) *Chairman;* A. J. McCullough (Brown Instrument Co.).

Plans were laid for an interesting and informative series of meetings to be announced later, which will start in late September. Officers for the year are: W. E. Sachse (Standard Oil Company of Ohio) *Chairman;* O. W. Heyman (Meriam Instrument Co.) *Vice Chairman;* A. J. McCullough (Brown Instrument Co.) *Secretary;* Mandal Estrin (National Advisory Committee for Aeronautics) *Treasurer.*

DETROIT

Since the first organizational meeting of the Detroit Instrument Society on March 19, 1945, two succeeding business meetings have been held.

On June 18, a very lively technical program was enjoyed by the more than sixty persons attending this meeting, held at the Ethyl Research Laboratories.

This program consisted of an Electronics Instruments Symposium led by M. Zucker of the Electronic Controls Corporation. Electronic questions and problems presented from the audience were discussed by a panel of three guest speakers. These speakers were: Paul Huber, Director of GM Proving Grounds; L. M. Ball, Head of Chrysler Sound and Vibration Laboratory; J. Lindstrom, Control Engineer for Westinghouse.

The discussions enveloped a wide range of topics in the field of Electronics, such as cathode ray oscilloscopes, strain gauges, vibration measurement equipment, and measurement of sound level.

All further meetings have been discontinued until next fall.

Plans are being made for the Detroit Instrument Society and the Wayne County Instrument Society to have a joint picnic during the summer.—CLIFF SACKETT, *Secretary*

PITTSBURGH

INSTRUMENTATION FOR TOMORROW EXHIBIT

As a result of travel restrictions, it will be impossible to hold the Instrumentation for Tomorrow Exhibit on the date originally scheduled, Sept. 17-21, 1945. The Exhibit Committee has changed the date for this Show to Sept. 16-20, 1946 and the same

Secretaries and Publicity Chairmen!

Keep your group in the news even during the no-meeting months! Send *Instruments* reports of committee work, items about individual members etc.—MFB

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If so, let us help you solve it with the Steinlite Electronic Moisture Tester . . . which tests a wide variety of products . . . grain, pop corn, nuts, cocoa, dehydrated eggs, carrots and many other products, and is constantly finding new applications. The fact that more Steinlites are in use than all other makes of electrically operated moisture testers indicates that industry recognizes the value of the Steinlite.

It is almost as easy to operate as a radio. No technical knowledge is required, and no previous experience. When used by an experienced operator it is "THE ONE MINUTE MOISTURE TESTER". Built by a pioneer organization of radio engineers . . . operates on the radio frequency impedance principle and is calibrated against official oven methods. Sold on FREE TRIAL basis. No money down. $325.00 F.O.B. Atchison, Kansas.

Easy to Make Moisture Tests with a STEINLITE

Almost anyone can learn to operate the Steinlite in a short time. No special education or training is necessary. About all one does is (1) weigh out a sample, (2) pour it into the Steinlite hopper, (3) read a meter dial, and (4) compare the reading with a chart showing percentage of moisture.

644 Brooks Building Chicago 6, Illinois

SEEDBURO EQUIPMENT COMPANY

space has been reserved at the William Penn Hotel for this period.

At the time the change was made, it appeared that the space rented would be inadequate for the demand, as there were only 27 unreserved booths remaining. Tentative arrangements have been made to secure additional space which will be offered first to those already holding space, in case a different location might be desired.

Those who wish to withdraw their reservations as a result of this change will receive the amount paid in, less ten percent of the cost of the space reserved. As stated in the contract, this amount is being retained to cover expenses involved in printing and distributing notices of the Exhibit.

On April 28, 1945 the Instrument Society of America was formed by the joint action of seventeen local societies. The A.S.M.C., which will later become the Pittsburgh Section of the Instrument Society of America, was requested to continue handling arrangements for the Exhibit which is now sponsored by the National Society. It is expected that this will substantially widen the interest in and attendance at the Exhibit.
—PAUL G. EXLINE, *Chairman, Exhibit Committee*

WYANDOTTE, MICH.

The current meeting of the Instrument Society of Wayne County had to be postponed until July 30. There was a very good attendance. We assembled at the entrance to the Socony Vacuum Refinery and received copies of the Socony Vacuum News. Several of our members are Socony men, and they conducted us through most of the plant. We saw several control rooms with well-designed instrument panels, including pressure and temperature control, remote transmission, and automatic sequence operation of valves.

After the trip we gathered in the plant restaurant and were treated to pie, ice cream, and coffee.

We enjoyed the trip very much, and we appreciated the efforts and hospitality of the company officials who made it possible.
—JOHN MACPHERSON, *Vice-President*

SOUTHERN CALIFORNIA METER ASSOCIATION

Mr. C. H. Van Marter, Training and Safety representative of the Union Oil Company of California, will present his "Table Top Demonstration of Basic Fire Facts" at the August meeting of the Southern California Meter Association, at the Rio Hondo Country Club, Downey, Calif., on August 16. Dinner will be at 6:30 and the meeting will start at 8:00 P.M.

The "Table Top Demonstration of Basic Fire Facts" will help to remove the fear of fire and will teach knowledge and respect for fire and will instill self confidence in prevention and control of fire.

Mr. Stanley D. Clithero, Assistant Engineer Fire Prevention and Control Department, General Petroleum Corporation, will present a motion picture, "Fighting Oil Fires." The film will give the fundamentals of combustion and the combustion characteristics of various common fuels. It will also illustrate the character and limitationse of fire extinguishing apparatus. The film will show fire fighting techniques and will include Chicago Fire School film on the fighting of real fires.

At the June meeting of the Association which is termed the "Low Jinks" and the meeting at which the officers are elected for the ensuing year Mr. R. N. Christiansen, Publicity Chairman last year, was elected to the position of Program Chairman. The writer was elected Publicity Chairman and asks that matters of publicity regarding the Southern California Meter Association be forwarded as follows:

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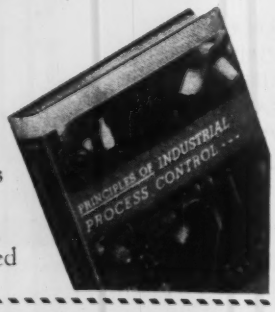

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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. To assist in the War Effort we urge readers to request ONLY those bulletins which will be of value to them. Use the coupon on the facing page.

M-204 **Facsimile Equipment.** 8-page 8½" × 11" booklet announces the manufacture of equipment which covers the entire field of facsimile. All types and sizes of facsimile and impulse recording equipment—using all the varied recording mediums; photographic paper, film, electrolytic paper, Teledeltos and ink are covered. Alden Products Company, Brockton 64F1, Massachusetts.

M-205 **Instrument Rental List.** 32-page 8½" × 11" spiral-bound catalog lists and classifies sixty items of instruments for production of vibration, measurement of vibration, measurement of sound, measurement of strain, determination of loads, forces and shocks, and computation of movement in time and space. A per diem rental service is listed subject to minimum charges and to discounts for more extended use. Waugh Laboratories, 420 Lexington Avenue, New York, N. Y.

M-206 **Radio and Electronic Equipment.** 36-page 8½" × 11" catalog illustrates and describes selected units of electronic equipment for improving production facilities and for assisting in research and development activities. The following items are immediately available—receiving tubes, industrial electronic tubes, G.E. industrial tubes, Dumont cathode-ray units, RCA test equipment, Triplett test equipment and panel meters, Precision test equipment, Jackson test equipment, Di Acro die-less duplicating tools, Mallory power supplies, industrial timers, Sola constant voltage transformers, Equipto tool room units, photo electric units, industrial switches, soldering irons and accessories, Skilsaw tools, Operadio sound equipment and inter-communication units, P.A. accessories, Mitchelite fluorescent lamps, and Pierceway wiring systems. Walker-Jimieson, Inc., 311 South Western Avenue, Chicago 12, Ill.

M-207 **Geiger Counter Spectrometer for Industrial Research.** 8-page 8½" × 11" booklet is a reprint of an article by H. Friedman, Naval Research Laboratory, Washington, D. C. The author discusses in detail the theory underlying X-ray powder diffraction and how the "Norelco" Spectrometer works, its performance and applications. North American Philips Company, Inc., 100 East 42nd Street, New York 17, New York.

M-208 **Portable Lance or Prod Type Pyrometers.** 4-page 8½" × 11" folder describes lance type pyrometer which provides a means of temperature reading within 2% of absolute accuracy. Weighing only 1¾ lbs., this instrument is particularly adapted to reading the temperature of molten metals (exclusive of ferrous metals) and liquids. Typical applications would include metal refining, melting non-ferrous metals, remelting, linotyping, electrotyping, cyaniding, salt and oil baths, and oil refining. The prod type pyrometer is used for hot, solid surfaces where the hardened and sharp pointed, open end prod-type thermocouples may be prodded against the surface being read. Of the same weight, 1¾ lbs., it has application for determining the temperature of sheet metals, engine heads, castings, bearings and billets. K. H. Huppert Co., 6830 Cottage Grove Avenue, Chicago 37, Illinois.

M-209 **Dial Light Sockets.** 14-page 8½" × 11" Catalog No. 101 describes with numerous illustrations the full range of dial light sockets for radio receivers and transmitters, test instruments, and electrical equipment. Diagrams of all types of mounting brackets are also included. Lenz Electric Manufacturing Co., 1751 No. Western Avenue, Chicago 47, Illinois.

M-210 **Variable Voltage a-c Power Supply.** 4-page 8½" × 11" Bulletin No. 88 describes in detail with schematic diagrams the unregulated "Voltbox" and the regulated "Voltbox". When the incoming line voltage is generally stable or a slight fluctuation of the voltmeter pointer does not interfere with the desired results, the unregulated instrument is indicated. However, many times it is absolutely necessary to maintain a constant output voltage and for such applications the regulated type is recommended. Superior Electric Co., Bristol, Connecticut.

M-211 **"General Radio Experimenter."** 10-page 6" × 9" May issue, Vol. XIX, No. 12, of this house organ features an article on "Vacuum-tube and crystal rectifiers as galvanometers and voltmeters at ultra-high frequencies." Also contains an article on "Spark-timing with the Strobolux." General Radio Company, 275 Massachusetts Avenue, Cambridge 39, Massachusetts.

M-212 **"The Bodine Motorgram."** 8-page 8½" × 11" May issue, Vol. 25, No. 2, of this house organ is subtitled the "Bodine 40th Anniversary." Covers the progress made by the Company during 40 years and shows pictorially the development of the Bodine line of motors from the early days to the present time. Also carrys an article on "Characteristics and applications of the Governor Motor." Bodine Electric Company, 2250 W. Ohio Street, Chicago 12, Illinois.

M-213 **"Precise Production."** 4-page 8½" × 11" issue No. 107 of this house organ features the Gibbs Swiss-type automatic screw machine. By means of drawings and photographs, the special Swiss principle of operation whereby the rotating bar feeds toward the tools, is thoroughly explained. Shown too are examples of the finish and precision possible without secondary machine work. George Scherr Company, 200 Lafayette Street, New York 12, N. Y.

M-214 **Comparator Projector.** 6-page 8½" × 11" folder describes the use of "Faxfilm" method by which an exact replica of a surface is made in clear plastic in less than a minute's time. Faxfilm Comparator Apparatus, Model C-1000, is a complete projection booth containing twin micro-projectors. Use of two first surface reflectors permits projection of two Faxfilm slides at full 100 diameter magnifications, the images, each 20" square, appearing side by side on the inspection table about six inches away from the projectors. Thus product finishes may be projected beside "Faxfilm"

standards for easy and accurate inspection and comparison. Rex D. McDill, 5109 Mayfield Road, Cleveland 21, Ohio.

M-215 **Screw Machine Tool for Turning Extra Small Parts.** 2-page 8½″ × 11″ folder announces the new Model 000RT screw machine tool for very small work. With this tool using rollers, it is possible to accurately turn parts as small as 0.075″. Turning carbide blocks in place of rollers, parts as small as 0.020″ can be turned. The tool bit is held rigidly in the tool holder which gives maximum support for heavy cuts. Bits can be removed for grinding and returned to the same precise setting with a minimum of adjustment. Fast accurate set-up eliminates much of the costly "down time" in screw machine shops. Boyar-Schultz Corporation, 2110 Walnut Street, Chicago 12, Illinois.

M-216 **Relays.** 54-page 8½″ × 11″ Catalog No. 10 entitled "Relays by Guardian" contains accurate illustrations, fully detailed specifications, suggested applications and operating data of the most widely used Guardian relays, solenoids, magnetic contactors and switch parts. They are offered as standard representations of factory production. Guardian Electric Manufacturing Company, 1400 West Washington Boulevard, Chicago 7, Illinois.

M-217 **"Balco News."** 16-page 9½″ × 12½″ issue Vol. 4, No. 9 of this employees' organ contains as the feature article, "Two days in Sampson Naval Training Center." Numerous other items cover the round-the-clock activities of the many employees. Bausch and Lomb Optical Co., Rochester, New York.

M-218 **Vibration Fatigue Testing Machines. 4-page** 8½″ × 11″ Bulletin 425 describes the company's line of "shake-down" test equipment for research and development laboratories as well as inspection and testing departments. An article tells how vibration fatigue testing of post-war products will insure the survival during and after the highly-competitive post-war period. Typical manufacturers, technical schools and government departments using these machines are also listed. All American Tool & Mfg. Co., 1014 Fullerton Avenue, Chicago 14, Illinois.

M-219 **Insulation Tester.** 8-page 8½″ × 11″ Bulletin No. 1785 announces and describes the U. S.-made midget "Megger" tester. This new production is made to exactly the same specifications as the former made-in-England model. These instruments for testing insulation resistance have self-contained hand generators which are always ready for use and which develop as much as 500 volts d.c. Ranges extend to 50 megohm using the "Megger" cross-coil true ohmmeter that is independent of the generator voltage or speed of the hand crank. James G. Biddle Co., 1211-13 Arch Street, Philadelphia 7, Pennsylvania.

M-220 **Electronic Level Controls.** 6-page 3½″ × 8½″ Bulletin No. E-100 describes how these instruments are designed for maintaining or keeping within desired limits, the level of any liquid or conducting solid within an open or closed tank, hopper or other container and/or indicating the level by signals. The control can be installed to operate solenoid or motor driven valves, pumps, bells or any other electrical devices. Trimount Instrument Co., 37 W. Van Buren St., Chicago 5, Illinois.

M-221 **Special Testing Instruments for the Laboratory and Factory.** 8½″ × 11″ Catalog No. 336 binder with indexes and bulletins. Additional bulletins will be mailed out from time to time. Bulletins issued to date cover general information, air flow measuring equipment, engine indicators, flow meters (rate of flow),

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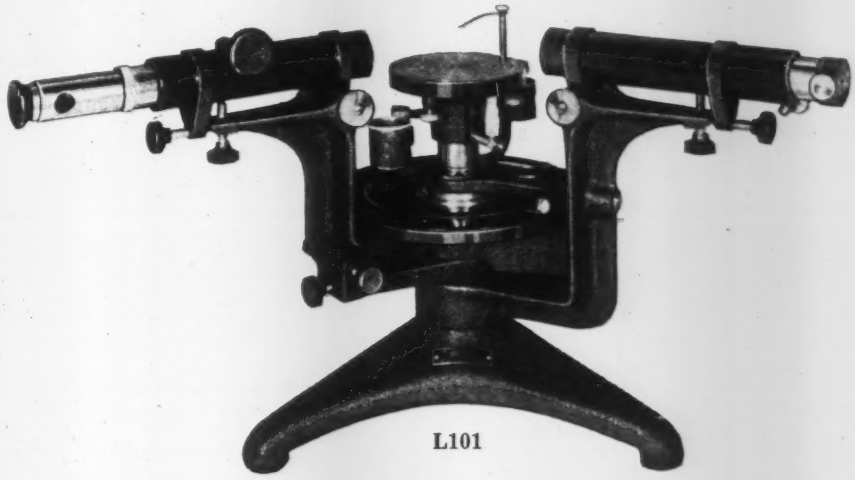

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Instruments, 1117 Wolfendale St., Pittsburgh 12, Pa. *(August 1945)*

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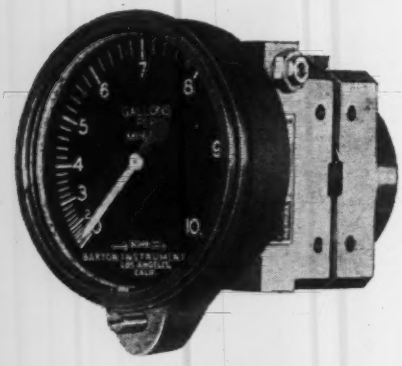

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magnetic thickness gages, Piezo-Ray equipment, rail car test equipment, slow motion equipment, sound study equipment, vibration study equipment and other testing instruments. Commercial Research Laboratories, Inc., 20 Bartlett Avenue, Detroit 8, Michigan.

M-222 **Grinding and Polishing Dust Collectors.** 4-page 8½" × 11" Bulletin No. 31645 describes three models of equipment used in collecting harmful dust in the jewelry, dental, novelty and other light-metal working industry. Details how the dust-laden air is drawn away from the work, strained through cloth bags and finally passed through a water bath to remove any fine particle that may have passed through the filter bags. The air is then returned clean and sweet to the work room. Leiman Bros., Inc., 146-181 Christie Street, Newark 5, New Jersey.

M-223 **"Tropicalized" Koolohm Resistors. 4-page** 8½" × 11" catalog features resistors for all radio and general service uses. All resistors listed are the "Koolohm" types having the tropicalized construction utilizing a glazed ceramic outer shell and a new moisture- and fungus-proof end seal. This construction eliminates the possibility of humidity and corrosion difficulties even under tropical humidity conditions. Sprague Products Co., North Adams, Massachusetts.

M-224 **Electric Controls for Heating, Ventilating, Air Conditioning and Industrial Applications.** 4-page 8½" × 11" bulletin F-2287-1 discusses the Barber-Colman electric system of temperature control which is available for heating, ventilating, air conditioning and industrial applications. Also described are the various room, duct, immersion, and remote-bulb thermostats which are available and the complete line of motor-operated valves, control motors, and package sets of control equipment for the maintenance of water temperature in hot-water storage tanks. Barber-Colman Company, Rockford, Illinois.

M-225 **Current Force Recorder.** 4-page 8½" × 11" bulletin GEA describes current-force recorder for welding machines, which includes an oscillograph for recording simultaneously a timing wave, the rapidly-changing electrode force, and the electrode current of a resistance welding machine while a weld is being made. This record is useful for periodically checking welding-machine performance, and for welding research. General Electric Company, Schenectady, New York.

M-226 **Electron Tubes.** 32-page 8½" × 11" manual for radio engineers and the War Industries. Gives complete, up-to-date information and technical data which will prove helpful in the selection of the right tube for each application and to obtain the highest efficiency from the tube itself. Taylor Tubes, Inc., 2312-18 Wabansia Avenue, Chicago 47, Illinois.

M-227 **"How and Why Cathode-ray Tubes Work."** 16-page 8½" × 11" booklet contains the following well-illustrated articles by J. R. Beers, Development Engineer: (1) Early history, (2) Mathematical concepts, (3) Present day problems, (4) Manufacturing problems, (5) Cathode-ray tube testing, and (6) Special Designs. North American Philips Company, Inc., 100 East 42nd Street, New York 17, N. Y.

M-230 **Cenco News Chats.** 22-page 8½" × 11" June issue, No. 29, of this house organ published to acquaint those actively engaged in laboratories of education, industry and medicine, with the latest development of apparatus and new applications. The featured articles are (1) Serving Science, (2) Notes, comments and correspondence, (3) Technical events and abstracts, (4) Corning Glass Works, and (5) New ideas for better work. Central Scientific Company, 1700 Irving Park Road, Chicago 13, Illinois.

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Instruments for Engineering Schools

THE UNIVERSITY OF TENNESSEE
KNOXVILLE 16
DEPARTMENT OF CHEMICAL ENGINEERING

July 26, 1945

Dear Major Behar:

I have read your editorial in the June issue of *Instruments* concerning Professor Cole's plea for a better method of acquiring instruments for the technical schools. This problem is one that has baffled me for some time and I have not yet found a practical answer for our chemical engineering curriculum.

Many schools—this one included—are in very poor financial condition because of the war. Even in normal times the appropriation is not adequate to purchase much new equipment. It is obvious that there are many classes of equipment other than instruments that must be bought. To attempt to set up an instruments laboratory by purchase is rather hopeless when one good industrial instrument takes a third of the departmental appropriation for maintenance and new equipment. So far we have been able to buy one industrial instrument about every two years.

We do not believe it is desirable to ask individual companies for donation of equipment, even though we think that the use of such equipment by the engineering student has an advertising value that should pay off well in the future. We furthermore expect that very little equipment that has any value will come to the schools from surplus war property. In fact, the regulations now provide that donation may be made to the schools only of property that nobody is willing to buy.

If it appears at times that the technical schools are not moving very fast in the field of instrumentation, I believe that the conditions I mention may be partly to blame. We would welcome an opportunity to get more equipment—but please do not send us some junk ripped out of an obsolete plant. We have enough of that now.

Yours truly

R. M. BOARTS
Professor of Chemical Engineering

Perhaps YOUR Lab Belongs in This Directory

NATIONAL RESEARCH COUNCIL
2101 Constitution Avenue
Washington 25, D. C.

July 2, 1945

To the Editor of *Instruments*

The compilation of the Eighth Edition of the National Research Council directory, "*Industrial Research Laboratories in the United States*," is now under way. The 7th edition appeared in 1940 and contained information concerning the industrial research laboratories of 2,264 companies and their subsidiaries. With five years intervening between the editions, it is expected that there will be a number of changes and it is hoped that a number of new laboratories will be added.

Although effort was made in 1940 to reach as large a number of laboratories as possible, no doubt some in each field have been inadvertently omitted. It is important that contact be made with these laboratories in compiling the forthcoming edition.

The term "research" for the purpose of the directory is construed as including investigations looking towards the IMPROVEMENT OF PRODUCTS or the REDUCTION OF COST OF MANUFACTURE as well as fundamental research and applied research. It does not apply to laboratories concerned only with commercial testing.

An announcement that the new edition of the directory is now being compiled would most effectively reach the laboratories in the field of scientific instruments through a statement in your journal. We hope that you will be willing to extend us this coöperation in an early issue.

Research men should inquire of the directors of their laboratories whether questionnaires have been received, as those reporting in 1940 will have had their printed statements sent for revision. *If no questionnaire has been received, one will be sent upon request to the Library, National Research Council.*

The directory is issued by the National Research Council with no expectation of profit. There is no charge for the inclusion of a statement regarding a laboratory in the publication and no obligation is incurred in furnishing data.

ROSS G. HARRISON, *Chairman*

"Labor Unions' Jurisdiction"

204 Ramona Ave.,
El Cerrito, Calif.
July 11, 1945

To the Editor of *Instruments:*

I note with regret that you have entered into a controversial discussion on Labor problems in the May and June issues of your periodical.

I have been working for one of the largest research laboratories in the country for the past eleven years as a technician. We have had Organized Labor in the plant for over five years and I have not experienced any of the difficulties which were cited in your magazine.

I have enjoyed your magazine for over a year and would like to continue doing so in the future providing you do not intend to enter the economic field as some of the employer dominated professional societies have done. I hope you will return to scientific discussions and let the instrument man solve his own Labor problems.

Yours respectfully,

L. H. BAYLEY

OUR COMMENT:

"Letting the Instrument Man solve his own Labor problems" is precisely what *Instruments* has preached and will continue to preach. As to the Labor *vs.* Capital Controversy, we've never entered into it, for the simple reason that "Instrumentation Benefits BOTH Capital and Labor" (see May '34 editorial bearing this title and numerous others*). As to "entering the economic field," all of us entered it as boys when we started working: what out-of-place controversy can there be about recognizing this simple fact?

—MFB

*including, for example, that of Jan. '43 in which we called certain industrial executives "a disgrace to Management."

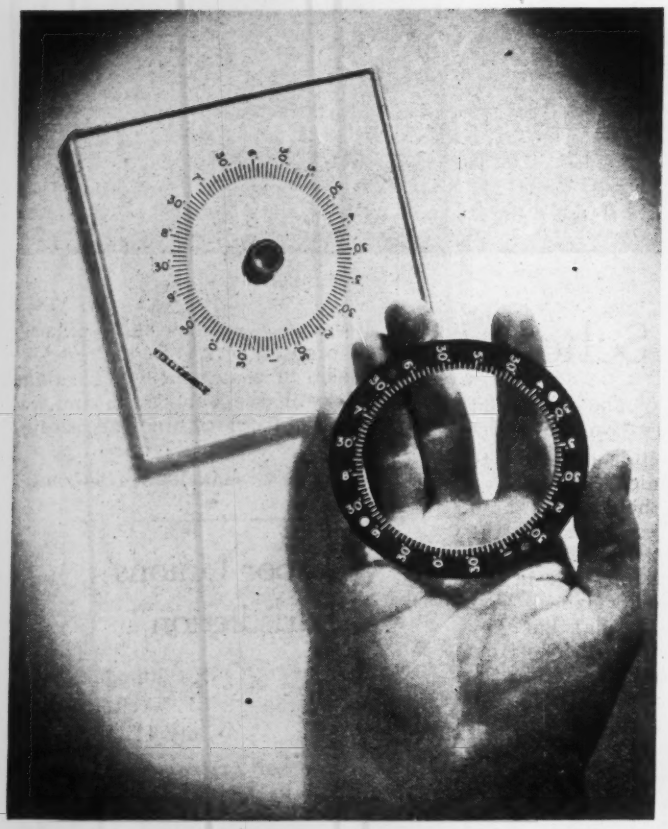
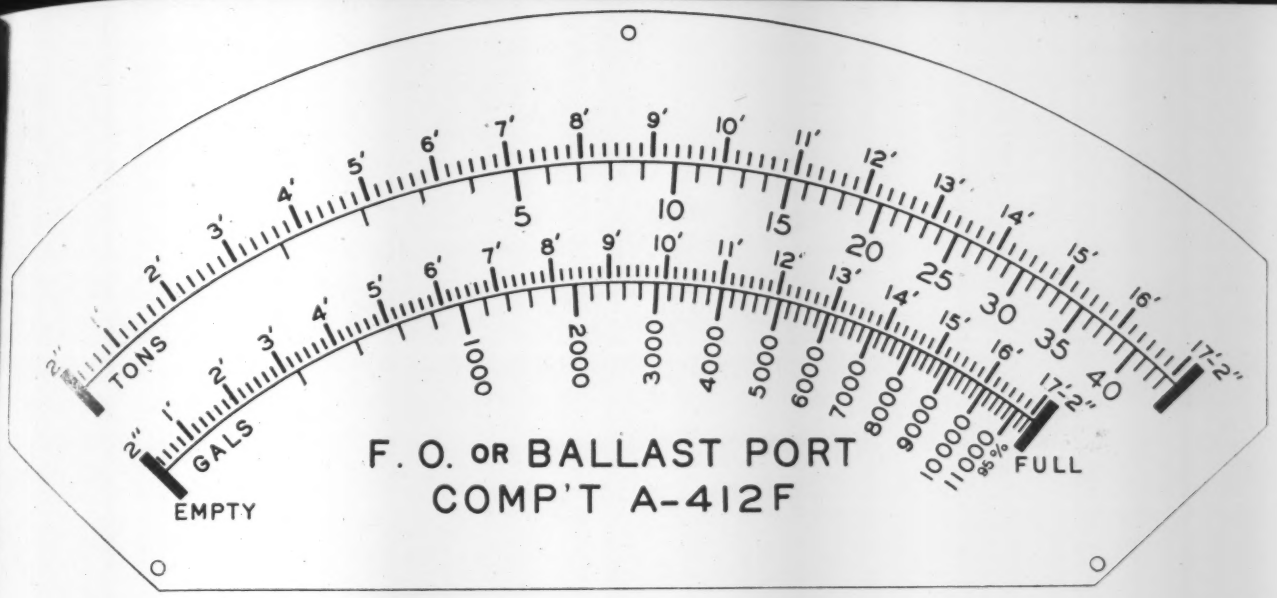


Fig. 1. Negative for precision dials is selected plate glass, drilled and bushed accurately, then sensitized and exposed. Metal and plastic dials are printed photographically.

Fig. 2. Plastic and metal dial blanks are sensitized by cementing them to Linagraph Transfer Paper, which is stripped away later, leaving a photo emulsion on the blanks.

Fig. 3. After exposing and processing (much like any photoprint) rough dials are washed in a cascade.

Fig. 4. Exact center hole is an accurate reference point for establishing inside and outside diameters on a lathe.



A New Photographic Method of Graduating Instrument Dials

By H. J. CHRISTY, Eastman Kodak Co., Rochester, N. Y.

MAKING dials under Navy specifications calling for accuracy to within five minutes of arc for electronically controlling the fire from a fighting ship or a bomber is a good trick—if you can do it.

Five minutes is the 1/4320 part of a circle—not much of a slice when the circle is only a few inches in diameter.

As usual, American engineers solved the problem and prevented a serious bottleneck in a highly critical precision part. And the way it was accomplished is interesting to everyone who likes to think in terms of accuracy to within minutes, or even seconds, of arc.

The engineers at American Dial Co., Inc., in New York City, reasoned that no dial could be exact if the center hole were drilled after the pattern had been put on it. So they attacked the problem in a different way—by first drilling a center hole in an optically flat glass plate. Then they cemented in a stainless steel bushing having a center hole accurate to within 0.0002". The next step was to sensitize the glass plate to light by cementing to it a special high-contrast film used by photo-engravers and to follow this by optically generating a dial pattern on the film.

The recording instrument incorporates an ingenious combination of optical and electro-mechanical principles and achieves a degree of accuracy both astounding and phophetic. For example, dial graduations can be made concentric about a polar axis or they can be generated around an elliptical axis. Spacings can be uniform, logarithmic, or follow any modified function. Patterns such as sine, square-top or saw-tooth waves can be made in any diameter up to 20", one cycle apart, and at any amplitude.

And although Army and Navy specifications now calling for dial tolerances in terms of 5 minutes of arc are thought in many quarters to be rigid enough, preliminary tests made on this equipment indicate that *absolute* accuracy may well be possible.

Since the dial negative is made on photographically sensitized glass, its dimensional stability becomes that of glass itself and, to maintain the original accuracy, a photographic printing method was decided upon, using the same sensitizing materials employed by many aircraft factories to make templates for aircraft parts at a great saving in time.

The sensitizing material, known as Linagraph Transfer Paper, consists of a thin, very fast emulsion held to a temporary paper support.

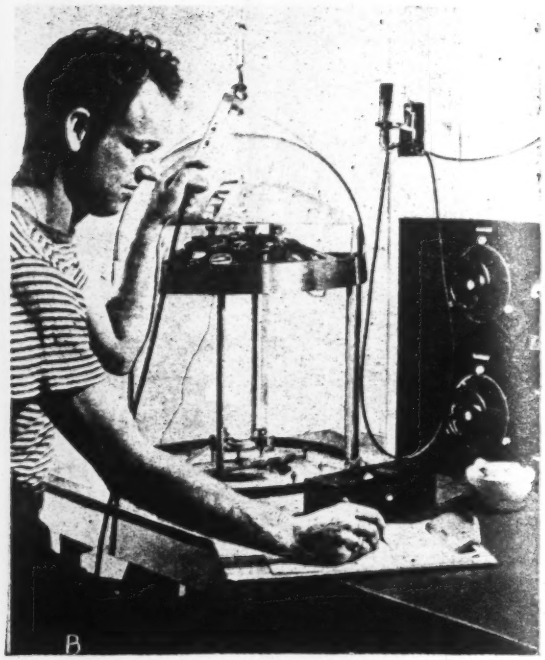
But before the dial material (metal for opaque dials, various plastics for translucent ones) is ready to be sensitized, it must be drilled as accurately as the negative plate (0.0002") and sprayed with Polymerin. The spray coat provides a suitable permanent support for the Linagraph emulsion and also forms the required background color for the legend—usually white, or green, or red, or a combination of the three, or Linagraph paper can be laminated without background color. Then the dial blanks are passed through a laminator which transfers the Linagraph emulsion to the blank from the paper support.

The rest of the procedure is simple. In a darkroom the face of the negative is laid in contact with the emulsion side of the blank and a stainless steel pin inserted through both center holes. The exposure is made, the two separated, and the blank developed, much like any photographic print.

After drying, the untrimmed dial is set up in a lathe with the center hole as a reference point, and the inside and outside diameters established with the lathe tool. Following a protective spray coat, rigid inspection and individual packaging, the process is complete.

In Long Island City, N. Y., the Liquidometer Corporation makes dials by virtually the same process but for a different reason. At present their business consists largely of liquid level gages for storage tanks on airplanes and ships—tanks for gasoline, fuel oil, potable water and alcohol (all calibrated in gallons), and water ballast (calibrated in tons and gallons). In spite of standardization there are only limited numbers of airplane and marine tanks that are truly identical, so most such dials are limited editions. They could be made with a pantagraph but this would require hours of skilled hand labor. They could be printed by offset lithography, but this is economical only for large production. The photographic method combines speed with economy.

Tolerances are not so close as those required for fire-control dials—15 minutes of arc against 5. Neither are exact center holes necessary. These relaxed requirements permit the negative to be made directly on film, instead of film-on-glass. But from here on the process is almost an exact duplication of the one at American Dial. And the significant point is this: Two employees make more dials in less time than would be required by ten people to do the same job by any other method!



In the Optical Shop at the Mare Island Navy Yard, Vallejo, Calif., lenses for naval instruments are given a coating of magnesium fluoride to improve their light transmission and field definition characteristics. Although the actual operation is carried out in an evacuated bell-jar, it is imperative that the room in which the lens are washed and otherwise prepared for coating be free of dirt and dust. Air entering the coating room is kept free of dirt by an electrostatic air cleaner, the Westinghouse Precipitron, capable of removing more than 90% of all dirt particles from 23,000 cubic feet of air each minute, which was recently installed there. In picture A, Roy Heisel, lens maker at the Navy Yard, is shown polishing out scratches in the course of preparing lenses for anti-reflection coating. In picture B, the vacuum bell-jar apparatus for depositing the coating is shown. Jim DeMartini, chemist at the Navy Yard, is checking the thickness of the coating on the lens in process, by noting the degree of violet coloration appearing on the lens in the jar when activated by a fluorescent lamp. *(Courtesy Westinghouse Electric Corp.)*

Notes on a Convenient Method of Minimizing Reflectance from Glass Surfaces

By Lieutenant Commander HAROLD B. SEIELSTAD, U. S. Coast Guard, "Somewhere in the Pacific-Asiatic Area."

BECOMING interested in minimizing reflectance of some large glass panels enclosing a revolving light, and learning that chemically treated glass did reduce such reflection, the writer tested sample lenses. He sought to determine if glass surfaces could be easily treated, thus reducing the reflectance of such panels. Infrequent as the application appeared at the time, its use has grown to enormous proportions in civil and military use with an interest unbounded and more and more of the glass and optical companies are presenting glasses and optical elements with a minimum of reflection difficulties. And finding that most instrument users—and many instrument makers—did not know of this improvement, it was thought high time for our magazine *Instruments* to give some data for the general industry.

Boiling a lens in hot water, freezing that same lens at 8° below zero F., scrubbing with abrasive powders to remove oily smudges, and have a lens remaining which looks cleaner and more transparent that a similar lens which was not treated to reduce reflectance, sounds like, but is no longer, a fairy story. In fact, from the description of a brief test which follows, demonstrations of the previous statements are readily observed. In the field of optics it seems to be an every-day necessity to treat lenses to reduce reflection, speed them up and reduce the spurious images or flares. To any instrument reader who must twist his neck to see properly manometer or thermometer columns, dial or other glass-enclosed indicating instruments—even the office clock—the grief attendant to reflections results in tiredness of eye and body with consequent inaccuracies in the "human equation." Relief which can be afforded by use of treated glass is nothing short of miraculous.

NOTE ON ILLUSTRATIONS

The author left to *Instruments* the illustrating of his article. We are responsible—not the Navy or the author. EDITOR

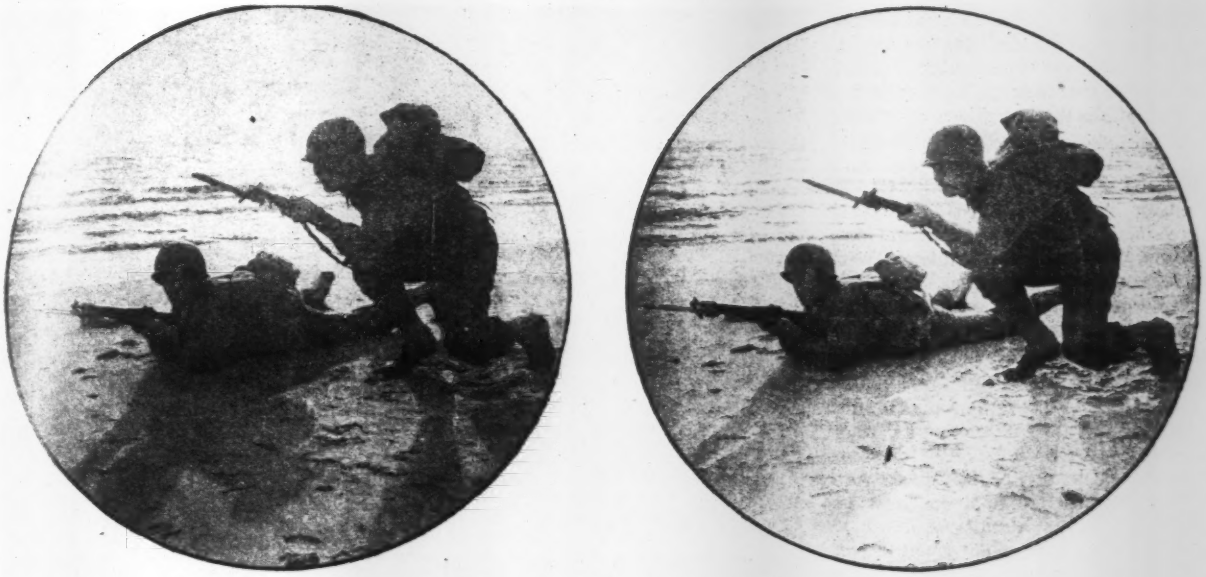
The writer brought results of his tests to the attention of Major Béhar with the suggestion that the apparent value of glass surface treatments be brought to the attention of men engaged in instrument work. As so often happens, the Major worked his wiles and got this whole bunch of words. He also contacted his many friends with experience in the treatment of glass surfaces and their accumulated experience is included with grateful acknowledgement throughout these notes. It is sincerely hoped that some of these words will ignite a spark which will lead to better instruments and their more convenient use.

For a practical experiment to determine the ease or difficulty of treating glass surfaces chemically, and to ascertain the value of such treatment, a Fresnel type lens was used. This is a common type lens used for lanterns, small river or bridge and obstruction lights and in aids to navigation along inland rivers, inter-coastal waterways, inlets and bays and some types of aircraft landing marking use. Those tested were manufactured by the Corning Glass Works and were 90-millimeter, clear, conical-top, flanged-base, pressed-glass lens, type No. 52091, composed of the heat-resisting variety of glass.

The light transmission of these lenses was measured by the candlepower readings on a Weston Model 603 illumination meter, it being assumed that a reduction in reflectance would result in an increase in light transmission. An aged, pre-focused base lamp manufactured by the Wallace & Tiernan Products, Inc., type No. FP-1612, rated at 6.2 volts, 0.7 amperes, was operated

Opinions and assertions are the author's and are not to be construed as the views of the Navy Department or the Naval Service at Large.

No objection to publication for Naval security reasons. Office of Public Relations, U. S. Navy, Review Section, 28 April 1945.



This striking pair of photographs may have been seen by many readers in recent advertisements. "Shooting into the sun" tends to kill details in the shadows, yet the photo at the right shows such details: it was taken with a camera having its lens treated with "Balcote." *(Courtesy Bausch & Lomb Optical Co.)* [All illustrations for this article are from unretouched photos.]

from a storage battery at 5.90 volts and 0.62 amps., held constant for each reading and continuously observed by instruments. The lens was mounted in a standard Coast Guard retainer ring clamp, on a rotatable indexed plate and aligned each time by the alignment marks cast into the lens. The lens was mounted in a box, which had its interior treated with a dull, lamp-black type paint finish. Light was conducted through a 3" diameter tube with the illumination meter paddle secured 25¾" distant from the center of the lamp.

Readings were made at eight different, reproducible settings throughout, and their results averaged. While this set-up was admittedly not a "laboratory standard," readings could be rechecked consistently throughout a number of rotations of the equipment. Of course, the same lamp and instruments were used throughout these tests.

The lenses were treated with a solution composed as follows: 2.1 grams of sodium fluoride per 200 ml. of water; 4 ml. of 50% sulphuric acid added to each 100 ml. of the sodium fluoride solution. The glass was "soaked" one hour in this solution.

Lens No. 1 averaged 4.875 candlepower under the above conditions untreated, and with the inside surface only treated gave 5.641 c.p., an increase of 15.7%.* A slight reduction was found from this value upon treating both the inside and outside surfaces but the lens was transmitting 5.508 c.p. or 12.8% more than when not treated. The change was no doubt occasioned by the change in thickness of surface treatment which, as is discovered in theoretical studies of the subject, should be one-quarter wavelength in thickness for maximum reduction in reflectance.

Lens No. 2 transmitted 5.061 c.p. before treatment and 5.531 c.p. or 9.3% more transmission after treatment of both surfaces simultaneously.

It may be well to point out here that only one type of glass was tested; that no effort was made to vary the strength of the chemical solution or of its composition, nor were other solutions tried. The length of time of treatment was not varied, nor were other tests made which are considered highly important. For example the nascent fluoride formation may be a contributing factor as indicated by Mr. Nicholl in his work with the Radio Corporation of America in which it was found that excellent results may be obtained from chemical vapors. Unfortunately the writer's military duties necessitated activities which did not permit exhaustive tests to be continued toward the end of 1941, therefore proof and substantiation of results is left to the literature, of which a bibliography is appended for reference.

To test the permanency of treatment, the lenses were weathered three cold days and washed with soap and water with a light transmission of 15.7% and 11.9% above the untreated glass. Again placed outside for weathering for six days, during which time the temperature attained a high temperature of 88°F. and low temperature of 8°F. below zero, with a full range of rain, sleet, snow, ice, thawing and melting in a dirty, smoky atmosphere as only St. Louis formerly produced, the increase in light transmission remained at 14.6% and 10.0% respectively after washing.

The lenses were placed in water which required 55 minutes to reach the boiling point, after which they were boiled vigorously for one hour or a total immersion time of one hour fifty-five minutes. Measurement of light transmission qualities indicated an increase in transmission over the untreated lens as 16.2% and 13.5% respectively. The lenses were so hot and the cooling so rapid that many of the sharp edges of the prismatic rings chipped off.

Next the glasses were subjected to a 48-hour ordeal of smoke and tan from a very poorly adjusted oil pot. After cleaning with rags and an abrasive scouring powder the lens looked clean but measured only 13.6% and 9.8% increase in transmission respectively. Further cleaning with alcohol, soap and water brought them right back up to 12.0% and 12.2% respectively.

After these varied and arduous tests, the conclusion was reached that the treatment did improve the transmission qualities of the glass and that the particular treatment was permanent for all practical purposes. The lens looked no different after treatment, except that it appeared extraordinarily clean and had a slight purplish tinge.

Most prominent in the results quoted is the large percentage gain in light transmission after treatment of the lenses: 9.8% to 15.7%. This appears to be greater than the approximately 4% gain which should ordinarily be expected; however, there appears to be a rational basis for this apparently extraordinary increase in light transmission. The percent reflection is a function of the indices of refraction of two media as light strikes their common boundary when passing from one medium into the second medium. The usual reflection loss for plane surfaces varies from approximately 4% to 6% per surface as a maximum. On this basis the recorded results should not exceed 8% to 12% light increase for a plane surface. Since, however, the Fresnel type

*This figure of more than fifteen percent—three or four times the usual—made at least one authority refuse to read the advance copy of Lt. Com. Seielstad's article beyond this sentence. However, Lt. Com. Seielstad gives an explanation several paragraphs below.—EDITOR.

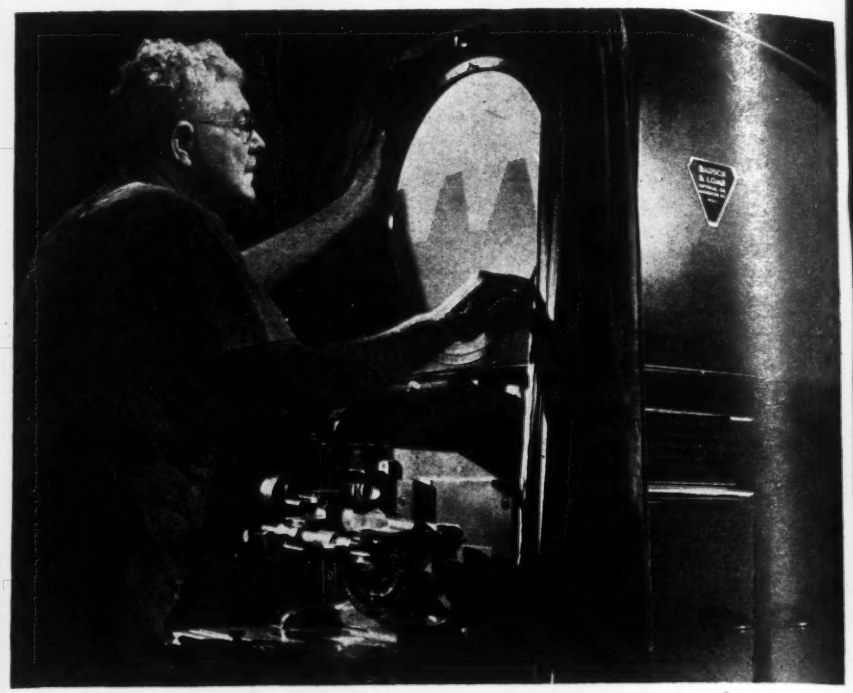
lens is designed so that a maximum horizontal directivity of the light is achieved, it appears reasonable to assume that an increase in light transmission over that of a plane surface might be expected. By a simple geometrical proof, utilizing a convex surface and comparing the result to a plane surface, an increase slightly greater than measured in this experiment results. This is on the assumption that 100% efficiency in coating is obtained, which obviously, would be impossible to obtain, therefore the results quoted appear reasonable.

An analysis of the averaged test readings after treatment reveals a maximum variation of 3.8% for one lens and 3.6% for the other lens. An idea of the relative accuracy of the measurement and permanence of treatment is thus afforded. This variation is of a magnitude which may also account for the difference or increase over that which might be anticipated. Had not such a standard rigid mounting been used along with an aged lamp bulb, it is very likely the results would have varied more widely and might have been of less value.

On the whole, the conclusion is easily reached that glass surface treatment is successful in reducing the reflectance from such surfaces and that an increase in transmission of light may be expected. As will be shown later, from other published works, many kinds of glass, and several types of treatments may be considered in any particular application.

Major Béhar submitted the notes which the writer had first assembled to a number of highly qualified persons in the Optical Industry for comment and criticism. In reply Mr. Wm. C. Miller of the Vard, Inc. Optical Department, and Dr. Walter Goldstein, Manager of Zenith Optical Laboratory, were kind enough to point out that the work above was authentic and borne out by other investigators. They, as well as all others, indicated that values obtained were somewhat higher than usually anticipated. Dr. A. H. Bennett, Director of Research for the Spencer Lens Company, Mr. Miller of Vard, Inc., Mr. W. P. Strickland of the Simpson Optical Manufacturing Company, and N. Brewer, Chief Engineer for Fischer & Porter, emphasized that the coatings or etchings on glass surfaces should be ¼ wave-length in thickness or some odd-numbered multiple of that thickness. Apparently the treatment given was approximately ¼ wave-length in effect, as can be determined from data given; a second treatment of one lens giving no appreciable increase in light transmission.

Mr. Lloyd Motz, Director of the Optical Engineering Laboratories, suggested that an easy method which can be tried by an amateur without the use of complicated and expensive apparatus is the immersion of the glass surface in a dilute solution of sodium silicate.



A 26% brighter screen image in this contour measuring projector results from an anti-reflection coating applied to condenser lenses. The coating is of the evaporated-film type developed by B&L to increase the light transmission of binoculars, telescopes, and photo lenses. *(Bausch & Lomb Optical Co.)*

Dr. Walter Goldstein, Manager, Zenith Optical Company, Dr. E. N. DelFosto of the Research Department, Semon Bache & Company, Mr. N. Brewer of Fischer & Porter, and Mr. Ferdinand Schurman, President, Fish-Schurman Corporation, were kind enough to suggest that this article would be of general interest to the Instrumentation fraternity. Dr. Richard S. Morse, President of the National Research Corporation, expressed his pleasure over the bibliography which had been assembled.

A most interesting explanation of the reflection phenomena, together with a very readable account of the whole subject is contained in Dr. Hubert U. Brueckner's letter to Major Béhar. The writer is happy indeed to quote this letter practically in its entirety with the kind permission of Dr. Brueckner and Binswanger & Co. of Tennessee with whom he serves as Director of the Laboratory Optics Division:

"Your letter of the 2nd of September brings up an interesting subject. I will attempt to give you as much information on the subject as I can without becoming too involved in either mathematics or optics.

"As I recall, it was about 1892 that H. Dennis Taylor, who at that time was engaged in the business of repairing lenses, observed that dull appearing lenses—lenses that were tarnished—transmitted more light than perfectly clean lenses. He surmised this to be due to a reduction in surface reflection and proceeded to experiment by artificially tarnishing lenses. He discovered that a lens tarnished with hydrogen sulphide increased its transmissibility without affecting the quality of the image, however, this film was very easily removed and did therefore not prove practical.

"Serious experimenting along these lines was again resumed during the First World War when it was found that such materials as acid sodium phosphate, boric acid, nickel sulphate, copper sulphate, potassium dichromate and many other substances produced stains that were more or less stable and increased the transmissibility of lenses.

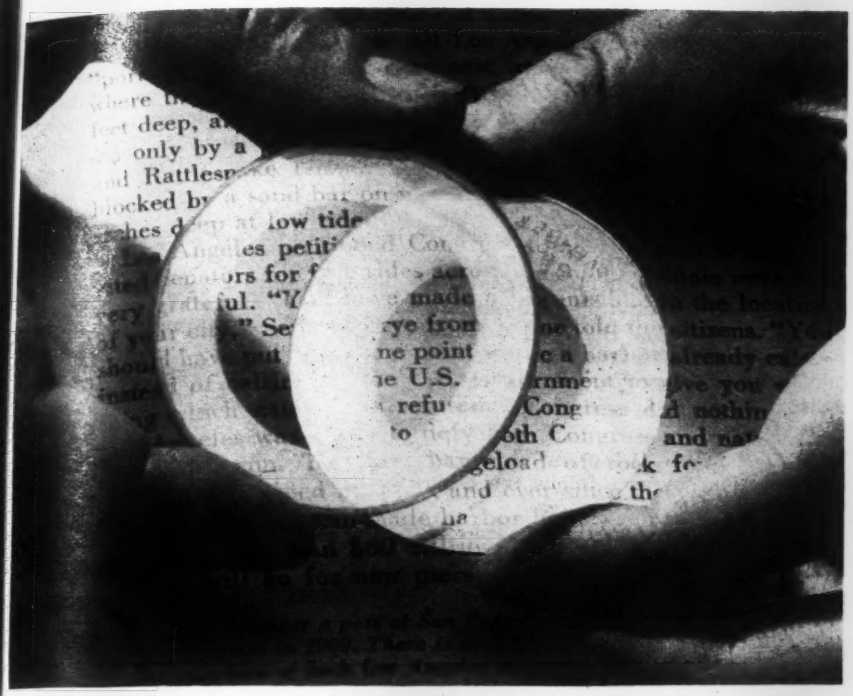
"Now whenever light is caused to pass from one medium into another and there is sufficient difference between the indices of refraction of the media, a certain percent of the light will be reflected at the boundary.

$$\% \text{ reflection} = \left(\frac{n_2 - n_1}{n_2 + n_1}\right)^2 \times 100$$

"This gives the percentage of light reflected where n_1 and n_2 are the indices of refraction of the two media.

"Where the media are two pieces of optical glass either in contact or cemented in contact, the percentage of light lost will be found to be negligible, about 0.2% or less. However, the loss of light by reflection at glass air boundaries is about 4% to 6% and this is in the case of a lens having six glass air surfaces results in a loss of ½:f.

"Aside from the loss of light-gathering power, an optical system, whether it be for visual or photographic work, can be made more efficient by properly treating all glass air surfaces so as to reduce reflection to a minimum and confine it to an unimportant part of the visual or photographic spectrum. Stray light thus eliminated from the optical system would have been the cause of 'ghosts' and reduced contrast and detail especially in the case where



Two overlapping glass disks with central areas coated with magnesium fluoride to reduce reflection. Note reduction of reflection-caused glare, and the increased visibility over the coated areas. *(Courtesy Scientific Instrument Division, American Optical Co.)*

an object would be viewed against a bright background.

"Now reduction and confinement of reflection to an insignificant portion of the spectrum can be accomplished in one of two ways; the principle involved, however, is the same in either case, namely, interference. The glass may be surface etched to a depth of ¼ wave-length by immersion in a solution of or exposure to fumes of certain acids. The acids to be used, so that complete control may be had over the operation at all times, depend upon the chemical composition of the glass. The etching must be stopped at the right instant or the lens may be ruined. Here you recognize Commander Seielstad's method. Sodium fluoride solution works fairly well with the boro-silicate heat-resistant glasses of which lighthouse lenses are made. However, for use with precision optics such as are found in instruments—the application in which I believe you are interested—a film is deposited upon the glass. For optimum conditions of a glass air boundary, the film should have a thickness of ¼ the wave-length of the light to be transmitted and a refractive index equal to the square root of the index of the glass.

"As mentioned before, various substances have been tried and of these it was found that the fluorides produce the 'hardest' films or coats. Magnesium fluoride is generally used. It has an index of refraction of about 1.38. From this it can be seen that it is slightly more efficient with the high index or flint glasses; however, the loss in efficiency with the crown glasses is so slight and the coating so comparatively durable that magnesium fluoride is now used regardless of the index of the glass with which it is used.

"It is applied by evaporation in a high vacuum, about 3×10^{-4} millimeters of mercury or less, the molecules of magnesium fluoride condensing on the surface of the lens, thus coating it. The thickness of the film is judged by the color of the reflected light. This may be done either visually or by means of the photoelectric cell. Today every well-equipped optical shop has a lens coating department. The Optics Division of the Binswanger & Company coats hundreds of optics daily for the use of our Armed Forces. Our coatings are substantially as hard as the glass itself, and it has been found that they improve with age.

"Hoping this brief review gives you the information you sought, I want to point out that we will be happy to answer any further questions you may have on the subject."

Technical literature (a short list of references is appended for convenience) explains this phenomenon on the basis of destructive interference set up by a film one-quarter wave-length in thickness. The film may consist of a molecular layer floated on the surface and may be built up to a number of layers as desired. This process was developed, with widest publicity, by Dr. Katherine B. Blodgett of the General Electric Company's Research Laboratory. She found that by dipping glass 46 times in a water bath covered with a monomolecular film of cadmium arachidate and arachidic acid, a film of required thickness was established on the glass. Washing with hot acetone reduced the index of refraction to a proper value.

Dr. John Strong of the California Institute of Technology developed, on theoretical grounds, that if a film one-quarter wave-length in thickness and with an index of refraction equal to the square root of the index of refraction of the glass upon which it is deposited, the intensity of light reflected would be zero. He obtained such a film by using high-vacuum evaporation technique. It is stated that the reflectance of his plate-glass specimens was reduced from 4 to 0.6 percent. This corresponds to an increase in total light transmitted from 92 to 99 percent for a glass treated on both sides.

A method similar to that used in the tests given above has been well presented by F. H. Nicholl of the Radio Corporation of America. He gives curves and charts for the types of solutions as well as the percentage change in reflectivity for length of time the glass remains in solution. Various types of glasses are also considered.

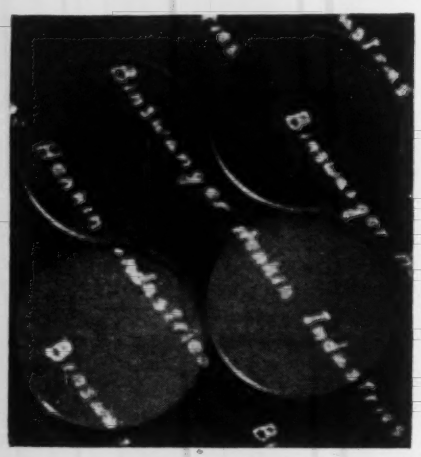
Use is made of treated lenses in various photoelectric cells and tubes, cathode-ray and television tubes, iconoscopes, optical systems for sound recording and reproduction and for photographers' lenses in newspaper and movie work. It is interesting to note that the definition and resolving power of lenses are definitely increased and that there is a noticeable improvement in image contrast and brillance. At the same time, flares, or ghosts obtained when photographing into a bright light, are eliminated. In William C. Miller's résumé of the subject an example of a photo shot at the sun giving 13 image flares is reproduced beside a scene taken by a treated lens under the same conditions in which only a faint single flare is found back of a well-defined image of the sun. Other photographic reproductions are startling revelations of gains obtainable for treated glasses. Apparently the betterment is not all a matter of mathematical percentages but an actual visual gain.

Amusingly, most persons have objected to glass surface treatments because of the tarnished appearance of the surfaces. This tarnished condition, however, was the cause of the original investigation into surface treatments. In 1892 the famous lens designer H. Dennis Taylor made careful measurements on such surfaces and found that instead of harmful effects the tarnished lenses produced images measureably brighter than did identical new, untarnished lenses. Subsequently he and others developed a chemical treatment to produce improved surfaces.

As amusing as is the reticence of most persons to use a "tarnished" lens, it has been reported that one movie studio achieving a peak screen illumination of 24,000 lumens with untreated projection lenses found an illumination of 30,000 lumens after treatment. Instead of a usual 10% to 20% gain, previous gains which were made subjects of loud rejoicings, a total gain of 6,000 lumens (25% in this case)

was actually found. A reason, indeed, for examining treatments of glass surfaces!

Frank L. Jones gives a highly illuminating account of the fragility of optical surfaces, analyzing the various surface effects and giving detailed accounts and reasons. A table of durability tests for optical glasses is given as well as a description of certain stabilization methods used. No doubt the greatest surprise of his revelations



Four instrument cover glasses 2⅛" in diameter and ⅛" thick are shown on a piece of black wrapping paper, two before coating, two after coating. Illumination was a standard overhead lighting fixture with three 36" "daylight" fluorescent tubes. The four disks were so arranged as to reflect maximum glare toward the camera. The reflection-reducing film consists of ¼-wave thickness of magnesium fluoride. The thickness of the film was so chosen as to reflect a minimum amount of light in the neighborhood of 5,500 A.U., the yellow-green region of the visible spectrum. The purpose of this application of the film is to reduce visible glare from the individual cover glasses of a large instrument panel. *(From an unretouched photograph made without filter on a panchromatic emulsion; courtesy Binswanger-Henkin Industries.)*

is the affinity of glass and water. He states that every time a lens comes in contact with water, whether by washing, with vapor in the air, condensation, or touching with the fingers, some reaction takes place. A reading of his article is highly recommended, and it is suggested that notes be made from the article and brought to the attention of everyone using glass — whether eyepieces or magnifiers, hardness testing microscopes, regular microscopes, phototubes, electric-eye apparatus, instrument telescopes—in fact any glass or lens through which light must pass unaltered.

While the test given in outline above was made out of curiosity; was so simple, inexpensive and yet proved of such value; it, together with the additional investigation of the quantitative work of others, reveals a vast, fertile field for further research. It is understood that most large optical companies are now prepared to give service on optical element treatments.

These, so far as known to the writer, include Binswanger & Co. of Tennessee, located at Memphis, Tennessee; Vard, Inc., Pasadena, California; Spencer Lens Company, Buffalo, New York; Simpson Optical Manufacturing Company, Chicago, Illinois; Optical Engineering Laboratories, New York City; Fischer & Porter Company, Hatboro, Pennsylvania; The Bausch & Lamb Optical Company, Rochester, New York; The Eastman Kodak Company, Rochester, New York; The Corning Glass Works, Corning, New York, the Radio Corporation of America, Harrison, New Jersey, and the National Research Corporation, Boston 15, Mass. This last-mentioned firm was, it seems, the first one to produce low-reflection coatings on a commercial scale: back in 1940.

Methods in use today for producing low-reflection surfaces follow the basic techniques:-

1. Mechanical application of films.
2. Chemical etching.
3. Vapor etching.
4. Evaporation in high vacuum.

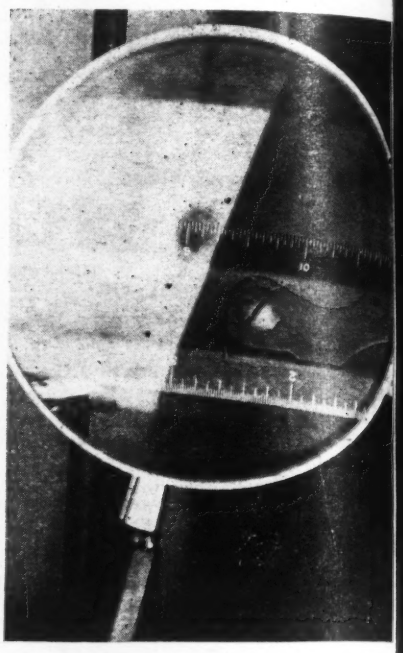
Mechanical application of film may be accomplished in the manner of Dr. Blodgett by floating molecular films on the surface to the depth required and reduction to the proper index of refraction by further chemical washing. Or it may be by simple immersion as pointed out by Dr. Lloyd Motz in his experiments with a dilute sodium silicate solution. In general this method does not develop a sufficiently hard coating, nor has the coating the desired permanence for most applications.

Chemical etching of the surface is a good method and a number of substances can be used. In this is recognized the method used by the writer. For glasses with irregular contours this method may prove most convenient. It is considered that the glass surface is etched by this process and a most intriguing argument may be developed over this question since glass is a heterogeneous mixture rather than a solution or homogeneous mixture. Complete control of this process is essential, otherwise a good surface may be ruined. Borosilicate type glasses respond well to this method. Chemicals used are generally of the halogen group, essentially fluorides and iodides in combination with metals. This method was developed by F. H. Nicoll. whose paper gives greatly detailed information, as well as a description of the vapor etching method.

In vapor etching a glass is supported so that the fumes or vapors from a hot chemical solution can freely pass over the surface of the glass. Greater control of the process can be achieved and it is not as detrimental to the glass as the complete immersion of the glass might be under poor control conditions. This seems to be the preferred chemical treatment. F. H. Nicoll developed the method to its present state of perfection.

Evaporation of metallic fluorides, generally magnesium fluoride, in a highly evacuated chamber, as described in Dr. Brueckner's letter quoted above, is the method in most general use. Dr. John Strong developed the theory of this method, and C. A. Cartwright developed the practical method of application.

Caution is required in the setting up of a lens treating department for most of the processes are covered by patents. Incidentally it may be of interest for



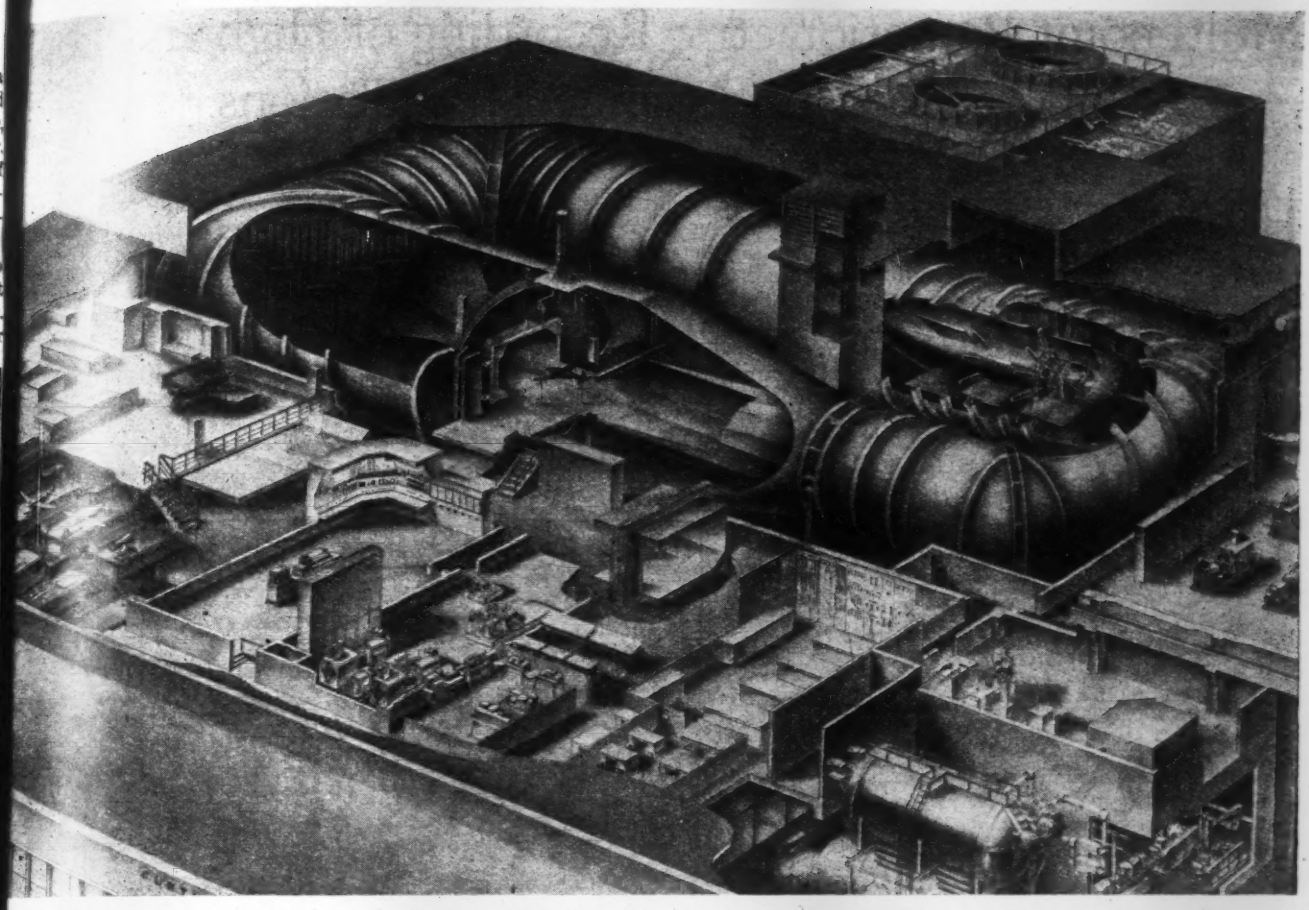
Left-hand half untreated; right-hand half treated. *(Courtesy Vard Inc.)*

those considering the development of such lens treatment to review the optical requirements for such treatments as set forth in Cartwrights' U. S. Patent 2,281,474 dated 28 April, 1942, in which the value of the deposition of a non-reflecting film is thoroughly considered.

Reduction of reflectance from glass surfaces may appear to be inconsequential when a maximum gain of only 4% per surface is anticipated. This gain appears only between glass-air surfaces or surfaces which have considerably different indices of refraction. However, that office clock is frequently just not see-able because of that small reflection. Likewise the time changes because of parallax as one shifts his head to see the hands. On a thermometer or manometer, or any similar tubular device, a reflection may prove serious in upsetting the reading. The discomfort caused the observer is simply not measurable.

Those advantages gained by simple treatment of surfaces as the clock face, thermometer, indicating instrument, glass-covered picture or chart, show cases or windows, and so on, seem practically insignificant — though a moment's thought reveals that they are considerable in the case of multi-element lenses—a camera lens for ex-

(Continued on page 564)



The control room shown in the front-cover photo (from Cardox Corp.) may be seen left of center in this artist's cut-away drawing.

Instrumentation of the Curtiss-Wright Wind-tunnel

By NELSON W. BURTT, Engineer, The Foxboro Company, Foxboro, Mass.

IN the publicity attending the recent inauguration of the mammoth new wind-tunnel of the Curtiss-Wright Corporation at its Airplane Division Research Laboratory, Buffalo, N. Y., little has been said about the instrument engineering involved. The explanation of this is in the fact that despite the huge proportions of the wind-tunnel, the control instruments are relatively few in number and, in spite of the extraordinarily wide range of test conditions, the operations of the control instruments are comparatively simple.

The installation does, however, have its unusual and interesting features. While it seldom is necessary, in these modern times, to cite reasons for the use of automatic control instruments, the objectives in the Curtiss-Wright installation might be stated thus: (1) to insure control of test conditions with precision and dependability; (2) to provide the desired test conditions, with maximum economy of time, power, and personal attention; (3) to insure the safety of material, personnel, and the wind-tunnel itself, against operational accidents. In connection with the wind-tunnel pressure control system, the control instrument is of the recording type, to meet a further objective: (4) to provide accurate chart records of test operations.

This article deals only with the instrumentation for the operational control of the wind-tunnel. It is not concerned with the many instruments employed in the actual testing of models.

The Curtiss-Wright wind-tunnel is like a huge oval doughnut, 378 feet in circuit length, and containing as much steel as goes into a heavy Navy destroyer. Its air volume is 210,000 cubic feet, equal to that of sixteen six-room houses. Two fans, 22 feet in diameter and working in tandem, provide any desired wind velocity up to many times tornado speed. Air pressure up to 60 lbs./in.^{2} gage, or approximately four atmospheres, is furnished by four heavy-duty compressors. At the other end of the pressure range, the tunnel may be evacuated to a pressure of 4 lbs./in.^{2} absolute, equivalent to the minimum pressure encountered in flight at 35,000 feet.

Actual testing is done in the test chamber (sometimes inappropriately called the "sphere"), a tunnel section measuring 8½ by 12 feet and capable of being sealed off from the rest of the tunnel by two air-tight doors. A third, similar door gives access to the test chamber from outside and is large enough to permit scale models with a wing-span up to 10 feet to be brought in on a test cart or platform.

Automatic control of static pressure within the tunnel and test chamber is provided by a Foxboro recording pressure controller, with a scale range from 30" mercury vacuum through zero to 65 lbs./in.^{2} pressure. An external setting knob permits the control point of the instrument to be set wherever desired, within this range. The controller, which is of the on-off type, pneumatically controls the valve motor in either of two parallel bleed valves, through which air is vented when the pressure reaches the predetermined control point, or air is admitted when the desired vacuum point is reached. The two bleed valves are of 4" and 6" diameter, respectively.

Test operations are controlled from a console in the control room. Only three men are required: a power operator, a balance operator and a tunnel control operator. The test chamber having been sealed off from the rest of the tunnel, the model plane is securely installed in place, the outside door is closed air-

(Continued on page 566)

Multi-point Potentiometric Recording of High and Low Potentials in Grounded Installations

By RAYMOND JONNARD, The Warner Institute for Therapeutic Research, New York.

FOR the purpose of computing engineering data it is often convenient to record on a single chart, by means of a recording potentiometer of conventional type, the simultaneous outputs of several thermoelectric junctions and the high-potential fluctuations in the corresponding automatically-controlled heating circuits.

When it is attempted to apply such

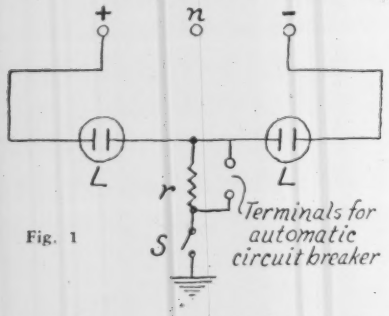


Fig. 1

a method to some industrial installations, difficulties may arise from two sources: (a) the existence of a common point for the thermocouple lines and the high-potential line, through the potentiometer circuit; and (b) the generation of stray currents in the complex circuit thus established.

The presence of a common point in the circuit is most troublesome. Indeed, most industrial a-c. or d-c. power supply lines are 3-lead balanced lines with the middle (so-called neutral) wire ungrounded. In such circuits, any accidental grounding of either one of the two "live" legs, even through a high resistance, shifts the potential of the "neutral" wire away from ground potential. If this were to happen when the "neutral" wire is connected to the "common" terminal of a potentiometric thermoelectric installation, the potentiometer would be immediately ruined by the short circuit to ground through the relatively low resistance of the thermocouple insulation and the almost unavoidable and frequently required connection of some part of the circuit to the housing of the instruments and to ground.

The eventuality of one power line becoming grounded can usually be detected by means of the auxiliary circuit shown in Fig. 1.

When switch S is on, the two glowlamps glow unequally, the brightest being on the side of the grounded wire. An automatic circuit-breaker can be operated by the eventual drop of potential taking place in the resistor r in this case. In several industrial installations we found the leaks to ground averaging as much as 500 to 700 watts, the "neutral wire" being at 70 to 90 volts above ground potential. In these installations, an automatic circuit-breaker cannot efficiently protect the fragile contacts of a recording potentiometer.

In order to obviate this difficulty, the following general-utility circuit was designed. It has been tested over a prolonged period of time.

The circuit is shown in Fig. 2. It is derived from that of Roberts[1]. The symbols H_1, H_2 and H_3 refer to the several heating elements under control, R_T being the total load resistances involved, and L a 1-watt glowlamp. The values of the resistors R_1, R_2, R_3, R_4 and R_5 can easily be adjusted according to the power consumed by the elements H, by means of the relations given below.

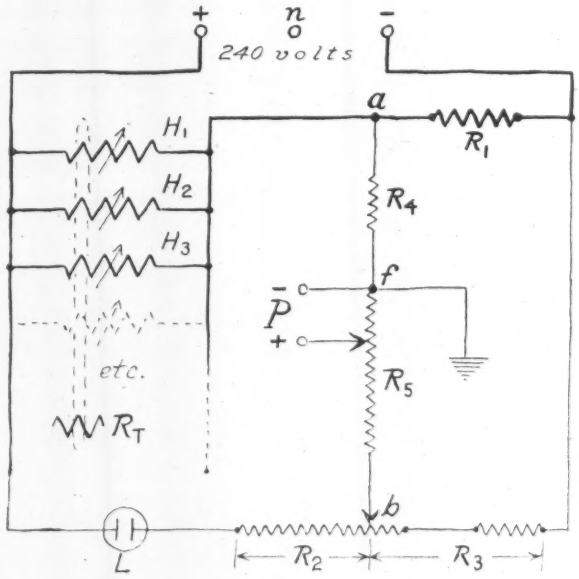


Fig. 2

The functioning of this circuit differs from that of the circuit devised by Roberts in that the total resistance R_T is practically independent of the temperature but varies by steps according to how many of the elements H are thrown into circuit by the automatic controller (or controllers). A relatively high steady current flows from point a to ground through R_1-R_3-R_5, and through H-L-R_2 and R_5. The potentiometer connected to the terminals P (with its "common terminal" connected to $P^{(-)}$) responds to any unbalance of the bridge resulting from a change in the compound resistance R_T, when the temperature controller (or controllers) throws the elements H alternately on and off.

At balance one has:

$$R_T/R_1 = (L + R_2)/R_3 \quad . \quad (1)$$

When the resistance R_T becomes $R_T + dR_T$, an e.m.f. e is generated between the points a and b of the circuit. This e.m.f. is given by the relation:

$$e = I\,(R_1\,dH)/R_1 + H \quad . \quad (2)$$

where I is the current flowing through H.

The deflection recorded is independent of the potential E of the power line, but the instrument records both the potential variations resulting from the variations dH, and the variations of the line potential. The value of e increases with the resistance R_1. The deflection due to the potential e may amount to about 10% of the applied line voltage: this is more than three times as large as the deflection caused by the accidental fluctuations of the line voltage. The stepwise variations of current accompanying each action of the temperature controller are clearly recorded, and the circuit has the added advantage of giving information about the variations of the line voltage due to the functioning of the heating installation itself as well as about those due to all other external causes (such as, e.g., starting an elevator). If the bridge were grounded at point b as usual, the effect of the line voltage variations would be much more important (relatively to the effects of heating load changes).

When all the elements H are off circuit, the instrument records a maximum deflection which reflects the variations of the line voltage due to external causes. This voltage applied to the

(1) Howard S. Roberts. Automatic control of laboratory furnaces by the Wheatstone bridge method. Temperature, Its Measurement and Control in Science and Industry. Reinhold Publ. Corp., New York, 1941, pages 604-610.

measuring galvanometer of the potentiometer through R_1 generates in R_5 a rather high current. But with the present method of grounding the circuit this current requires considerably less shunting of the galvanometer (through a section of resistor R_5) than when point b is grounded. As a consequence, the sensitivity of the potentiometer to the variations of the e.m.f. e is increased.

It should be remarked that a similar arrangement was proposed by Ribaud[2] for the supply to a pyrometric lamp by the so-called "method with constant resistance." But obviously, with the low voltage required in this case, little energy had to be dissipated by the various resistors, and grounding of the circuit was not necessary. However the complete theory given by Ribaud holds also for the circuit described here.

For operation on an a-c. power line, a Cenco No. 94180 vacuum thermocouple rectifier can be interposed at points P between the bridge and the recording potentiometer, and the contact on R_5 adjusted in order to obtain a proper deflection after rectification.

White[3] called attention to the importance of correctly shielding the thermoelectric lines in order to protect sensitive potentiometric measuring apparatus from the effects of stray currents generated by either a-c. or d-c. power lines in the vicinity. In the circuit described, there is intermixing between power lines and thermocouple lines: grounding of the thermocouple connecting boxes and line shields would not be enough to prevent stray currents from affecting the readings. But it is to be remarked that one of the potentiometer terminals is directly grounded. Consequently this same terminal can also be electrically connected to the sheath of the thermocouple lines, the shell and any other metallic parts of the ovens or other heated units, and possibly one or several of the thermocouples themselves. This arrangement thus becomes similar to that recommended by White for the potentiometric measurement of a current through a coil. It has also the advantage of effectively shielding against stray currents and stray a-c. fields causing asymmetrical electrostatic attraction between the galvanometer coil and the poles of the magnet inside the recording potentiometer, a circumstance frequently encountered in large industrial buildings.

(2) Gustave Ribaud. Traité de Pyrométrie Optique. Revue d'Optique Théorique et Instrumentale, Paris, 1931, page 335.

(3) Walter P. White. Potentiometers for Thermoelectric Measurements. Temperature, Its Measurement and Control in Science and Industry. Reinhold Publ. Corp., New York, 1941, pages 265-78.

and: Leakage control in shielding. *Ibid*, pages 279-83.

Errors Resulting from Using Compensating Leads With Chromel-Alumel Thermocouples*

By JOSEPH SPACEK, Aluminum Co. of America, Kansas City, Kansas

TWO factors are usually taken into consideration when installing extension lead wires in use with chromel-alumel thermocouples—cost and accuracy. Of these two, accuracy is dealt with too lightly, and in many cases the installer, instead of using true chromel alumel extension lead wires, will instead use so-called compensating lead wires, since the cost in a large installation is considerably less.

Copper and nickel-copper extension lead wires are generally used in conjunction with chromel-alumel thermocouples. Referring to the diagram, it is obvious to see that the junctions X, between chromel and copper, and Y, between alumel and copper-nickel, each represent a thermocouple exactly the same as does the hot junction of the chromel-alumel wires.

These two junctions are therefore two sources of e.m.f's. The e.m.f. generated at X acts in opposition to that of the hot junction of the thermocouple, while the one at Y acts as a booster on the thermocouple. Therefore, the e.m.f's. at X and Y oppose each other, and if they were of equal values, the one would compensate for the other. Hence the term "compensating" lead wire.

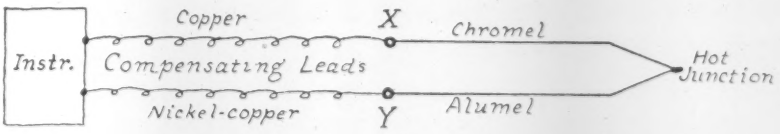
It is a common belief that these e.m.f.'s do compensate each other. But with the present-day pyrometer made with such a high limit of accuracy, it will be interesting to see just how close this compensation really is. If the compensating leads do not compensate, this fact entirely nullifies the fine accuracy of the instrument and the chromel-alumel thermocouple being used.

Since the junctions X and Y are the connections between the lead wire and thermocouple, it is obvious to see that they will be located close to the hot furnace in which the thermocouple is inserted. Often they attain a temperature in the neighborhood of 300°F.

If the compensating leads actually compensated, this high temperature would have no significance. The fact is, they don't compensate, which introduces an error, as will be shown.

Based on U. S. Bureau of Standard figures: At 300°F., chromel *vs.* copper X, generates 3.07 millivolts, and at 290°F., 2.94 millivolts.

Based on published specification values for the nickel-copper combination: At 300°F., alumel *vs.* nickel-copper Y, generates 3.51 mv., and at 290°F., 3.38 mv.



CASE 1: If X and Y are each at 300°F., it means that there are 3.07 mv. at X opposing the e.m.f. of the thermocouple, while there are 3.51 mv. at Y, adding to the e.m.f. of the thermocouple. These figures should be the same, but they are not, and the resultant error is their difference, or 0.44 mv., equivalent to adding a plus error of 20°F.

CASE 2: Suppose that X is at 300°F. and Y at 290°F. In this case, as above, 3.07 mv. oppose the thermocouple, while 3.38 mv. add to it. This makes a plus error of 0.31 mv., or 14°F.

CASE 3: Now let X be at 290°F., and Y at 300°F., the reverse of Case (2). This means 2.94 mv. will oppose the thermocouple, with 3.51 mv. boosting it, causing a plus error of still greater magnitude of 0.57 mv., which is equivalent to a high reading of 26°F.

Therefore, in the neighborhood of 300°F., a plus error exists ranging from 14°F. under the best conditions, to 26°F. in case of slightly uneven heating of X and Y.

The above errors can be entirely eliminated by using lead wire of the same material as the thermocouple, thereby actually extending the thermocouple clear to the instrument.

*Substance of a talk before the Kansas City Industrial Instrumentation Society, Kansas City, Missouri, February 27, 1945.

METAL BELLOWS—An Outstanding War Device

By J. E. HART, Industrial Instrument Branch, War Production Board, Washington, D. C.

THE highly important part that metal bellows have played in the present global war merits the fullest possible recognition compatible with military security.

The commonly accepted definition of a metal bellows is, "a flexible, expansible, and collapsible metal vessel consisting of a series of annular plates having their inner and outer circumferences joined together by curved surfaces."

In peacetime, this 40-year-old device was used in heating, ventilating, refrigeration and automotive thermostats, thermostatic traps, shaft seals, control valves, regulators, measuring and control instruments, and for similar purposes. In wartime, it has been outstanding in the field of remarkable technological developments. American scientists and engineers have chosen metal bellows to effect the sensitive, precise, and dependable action in countless inventions which are destructive to the enemy and a boon to the Allied armed forces.

In mines, depth charges, aerial torpedoes, and bombs, metal bellows unleash devastating power. In airborne uses, the device serves both plane and crew for practically every essential need from landing gear to anti-blackout suits. The various oxygen regulators whose proper functioning is the guardian of a man's life at high altitudes, the cabin heater controls which combat the bitter numbing cold of the stratosphere, the turbo-superchargers and fuel injection devices that speed the planes, the engine indicators and thermostats that protect the power plants, the navigation aids that guide their flight and, finally, the fire control mechanisms, all use in single or multiple stages this ingenious little unit.

In military vehicles, in Navy, and Maritime vessels, in communication equipment, in electron equipment, in secret, special mechanisms, and in industrial, medical, and research instruments, it performs a multitude and variety of services that are unique, mostly new, and vastly important.

Functionally, the major basic uses of a bellows are: (1) To accomplish barometric compensation; (2) to accomplish fluid or pressure seals on rotating shafts or moving stems; (3) to act as an integral part of flexible couplings; (4) to provide for fluid expansion in closed vessels; (5) to act as an expansible member as in pressure and temperature indicating, recording, and controlling instruments, and (6) to transmit motion as in valves and regulators.

By method of manufacture, metal bellows fall into two broad categories: (1) Formed from a tube; (2) built up by soldering or brazing a series of formed disks.

Most metal bellows are made from thin gage metal varying between limits of 0.004″ and 0.010″. Brass, bronze, Monel, stainless steel, and beryllium copper are suitable materials, with 80-20 brass being most commonly used. Sheet metal is the base from which the tube is formed by the cup and draw method. After the tube has been processed to size, the bellows is formed either by a series of rolling operations deepening the corrugations successively as desired or by hydraulic forming with internal pressure and endwise mechanical movement on a split collapsible die.

From the engineering viewpoint, the main considerations in a bellows are: (1) The spring rate or flexibility; (2) pressure resistance; (3) mean effective area; (4) life.

Bellows procurement is a matter of months, not weeks. The manufacture of a plain metal bellows, even with material, tools, and dies available, is a time-consuming process. The die changes in the series of drawing operations and the in-between annealing, pickling, and trimming of the severely worked metal is a slow procedure, at best.

More than 25 separate operations in the formation of a bellows are not unusual. The extremely thin wall of the tubes requires perfectionist treatment in set-up, handling, and inspection. Owing to the absolute need for dependable functioning and maximum life, rejects are high, unavoidable production gaps caused by faulty material or tool and die deterioration are frequent and sometimes result in complete loss of material procurement and manufacturing time on individual batches. Small-quantity runs, the necessity for changing furnace operations for different metals, and sudden upsets in schedules for various other reasons, usually have serious effects on production goals.

A bellows assembly which may be a complete packless valve, turbo-supercharger regulator, bubble type sextant, servo unit, or one of a great many other necessary adjuncts to modern military equipment, complicates the purchasing problem. Sub-contracting on a wide scale is undertaken of necessity, and large quantities of anti-friction bearings, fractional h.p. motors, castings, forgings, and machined parts are used.

Five companies in general comprise the bellows industry. One is the primary advocate of "built-up" bellows. Another works solely in the field of stainless steel. The remaining three are almost exclusively manufacturers of tube type bellows produced by rolling and/or hydraulic forming. A few other companies manufacture limited types, but only for incorporation in their own special products. This handful of companies has borne the brunt of all requirements of the United States and for most of the British Empire.

ENGINEERING AND PRODUCTION PROBLEMS

The surge of war orders did not begin to exert real pressure until the middle of 1942. By that time, some of the skilled personnel in this extremely small field had been irrevocably committed to other war work or to the Armed Forces. As orders swelled in volume, they also increased in variety and intricacy, adding engineering burden in infinite detail and introducing tool design problems and production and material procurement difficulties of considerable magnitude.

Orders for sample lots, all different, all necessitating special characteristics, closer tolerances, and new tools, pyramided the work. Unusual applications became common occurrence, and so-called standard specifications were not sufficiently adaptable to lighten the load. The bellows principle seemed to fit the need of most of the new technological developments and, since it constituted the essence of many, more and more of the complete assembly work was turned over to the bellows manufacturers whose techniques for handling, filling, and calibrating the metal bellows helped produce precision instruments of maximum quality with minimum loss. As these new creations measured up to expectations under test, the full impact of the large production orders was felt.

The industry faced this immense task with a limited supply of special equipment and skilled personnel, but with a thorough knowledge of bellows design and practice. All possible production aids were explored. Responsibility for the product, previously split at least three ways, was assigned by mutual consent to one industry division. A production consultant devoted full time to a crusade for increased production, better understanding, advance ordering, and reduction of rejects by the users, as well as realistic appraisal of needs and full coöperation and support by the military claimants. Through the assistance of the claimants and industry divisions, new equipment finally was procured, labor recruiting urgencies were assigned and, in certain instances, highly trained men were placed on temporary inactive duty from the Armed Forces, to better utilize their talents in the plants.

Orderboard scheduling under WPB Order M-293 was initiated early for all orders identified by government prime contracts. All interested government procurement agencies and as many private groups as possible were advised to allow four months for metal bellows and six months for bellows assemblies.

Manufacturers of components generally were encouraged to place orders with realistic schedules for the longest practical periods.

Under present conditions, larger requirements for plain bellows can be filled with available manpower and equipment, provided that material can be obtained and that about two months be allowed for manufacturing after receipt of material and tools. For bellows assemblies generally, two months should be added to the bellows cycle. All foreseeable requirements can be met if orders are placed on time to allow for reasonable material procurement and manufacturing procedures. Late procurement, particularly on new items where quick deliveries are requested, will continue to cause trouble, since real short cuts are impossible for all practical purposes. Inasmuch as bellows and bellows assemblies are scheduled for all orders bearing government prime contract numbers, it is recommended that such data always be included where practicable.

An "Exposition on Paper" of Historic Bellows

By M. F. BEHAR, Editor, *Instruments*, Pittsburgh, Penna.

ON the occasion of the hundredth anniversary of the invention of the bellows-element pressure-measuring instrument the *Journal of Scientific Instruments* (London) published in its March 1944 issue a long article entitled "The History of Pressure-responsive Elements" by Dr. L. B. Hunt. This is a fascinating account in which many details long buried in obscure records of forgotten patent suits are told for the first time in a connected manner. Dr. Hunt's article is profusely illustrated with photographs and line drawings. Some of these latter are the historic drawings made for the Patent Office of France.

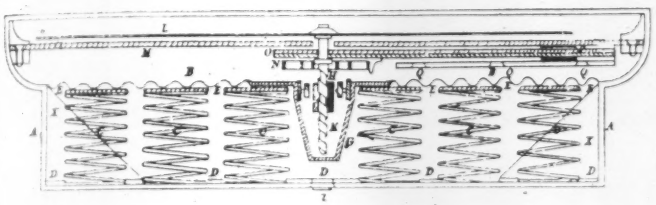


Fig. 1

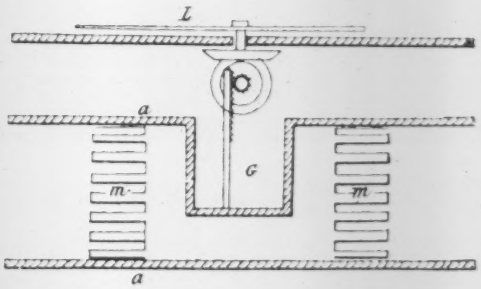
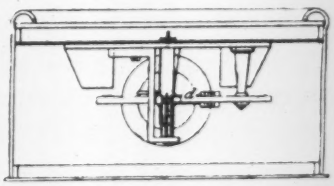


Fig. 2



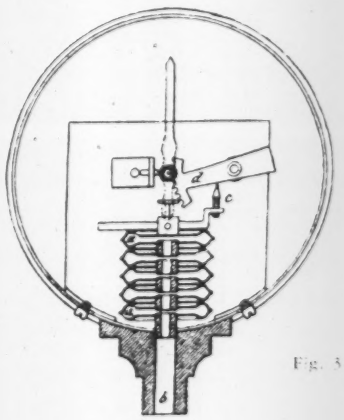


Fig. 3

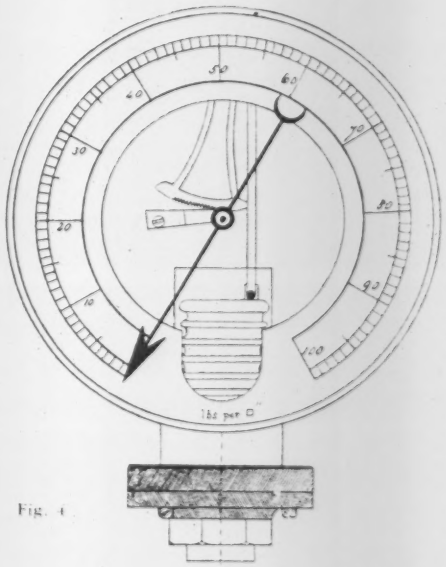


Fig. 4

The article by J. E. Hart of the WPB evidently deals with the *modern* form of the bellows element (to which he refers as a "40-year-old device") and specifically with war-time applications. Many of these applications are secret; and consequently Mr. Hart's article is not illustrated. It might have been interesting, of course—if it had been permissible—to print illustrations of these ultra-modern developments together with some of Dr. Hunt's historic pictures. However, "half a loaf is better than none" and we reproduce a few of the drawings from Dr. Hunt's article.

Most astonishing fact related by Dr. Hunt is that in 1844 the first inventor of a flexible-member pressure-responsive element conceived and patented the idea that such an element could be made into either of two forms: (1) a diaphragm with concentric corrugations for utmost sensitivity as in barometric measurements, or (2) a deeply-corrugated tube.

This man was, of course, Lucien Vidie, whose name shall live forever in the annals of Instrumentation because he designed and named the first aneroid instruments. Vidie, a lawyer and amateur astronomer of Nantes, became famous almost overnight because his *diaphragm*-type instruments took the scientific and technical world by storm. Vidie did not develop commercially his seamless-tube bellows -- no doubt because in the middle of the nineteenth century there was not an artisan on earth who could produce deeply-corrugated tubes of the requisite quality and uniformity. The fact, remains, however, that Vidie invented the seamless-tube bellows element at the same time that he invented the diaphragm element. Figs. 1 and 2 are both from his 1844 patent drawings.

The first "bellows-type" pressure gage of which there is any record was patented by Louis Andrée in 1849 but—as may be seen from Fig. 3—its responsive element was not a seamless bellows: it was a series of five capsular diaphragms of silvered brass. This gage was for use on locomotives. The then-new steam railway industry offered commercial inducements to inventors of non-fragile pressure gages and that same year saw the issuance of Bourdon's historic patent.

Skipping thirty-six years we come to 1885 when C. F. Wright patented in England a pressure gage having a corrugated seamless tube as its measuring element (Fig. 5). Eighteen years later, in 1903, W. M. Fulton, then Professor of Meteorology in the University of Tennessee, filed a patent for the bellows element which has come to be known as a "Sylphon" and began also his ingenious improvements of the processes for manufacturing it.

ELECTRIC GAGING METHODS
For Strain, Movement, Pressure and Vibration

By HOWARD C. ROBERTS, Research Staff, Association of American Railroads, Chicago, Ill.

XII. INDICATING AND DETECTING INSTRUMENTS
(Continued)

§ 2. Alternating-current Instruments—General

Satisfactory indicating or recording instruments for alternating-current applications are much more difficult of construction and application than are the corresponding instruments for direct-current use. This condition arises as a direct result of the characteristics of the alternating current.

If an instrument is to be used in an a-c. circuit it must have these characteristics:

(1) It must be sensitive to magnitude of current flowing —either instantaneous magnitude or average magnitude;

(2) It must *respond* to currents varying at a rapid rate —although it need not in all applications *reproduce* these variations; and

(3) It must possess one other characteristic in addition to the first two—this may be frequency-sensitivity, phase-sensitivity, or perhaps aperiodicity, depending upon the desired application.

Thus, if only *magnitude* of current is to be measured, the instrument must respond to magnitude (either effective or peak magnitude) without discriminating against frequency. If *frequency* is to be measured, the instrument must be sensitive to magnitudes of alternating current, and also

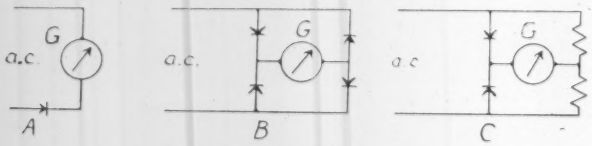


FIG. 185

must be discriminatory in frequency. If *wave-form* is to be recorded, the instrument must respond accurately to the magnitude of the alternating current, and must follow faithfully each variation as it occurs. Other requirements will be apparent in other applications.

As corollaries to the three characteristics listed, these general statements may be made:

For indication of magnitude only it may be desirable to employ an instrument having no specific sensitivity to frequency—as a rectifier-type instrument, a thermocouple or a dynamometer-type instrument.

For delineation of wave-form the natural frequency of the instrument must be high compared to the frequencies being recorded, and there must be no mechanical or electrical resonance within the operating range.

For measurement of frequency (or for detecting a specific frequency) a highly resonant system should be used. Greater sensitivity as well as discrimination against signals is thus available.

In the particular application of an instrument as a bridge-balance detector, it is most convenient to use an instrument sensitive to both the magnitude of the unbalance current and its phase with respect to the exciting current. With such an instrument, both direction and magnitude of unbalance are indicated, and adjustment of the circuit is facilitated.

Because of their manner of construction, a-c. indicating and detecting instruments have lower sensitivities than d-c. instruments. It is entirely possible, however, to employ electron-tube amplifiers to raise the level of the signal until its measurement becomes easy. Such amplifiers make possible the use of certain devices which, either because of intrinsically low sensitivity or because of the attenuation caused by their presence, cannot otherwise be used.

In the treatment which follows, only representative forms of these instruments can be described; for detailed descriptions—and for descriptions of other instruments—reference should be made to the extensive literature.

§ 3. A-c. Instruments: Magnitude-sensitive.

The most elementary class of a-c. instruments includes those sensitive to magnitude only. Such instruments are ordinarily employed for indicating average or r-m-s. values of current or potential and are used only in circuits carrying sinusoidal currents; they are not capable of accurate indication of currents of irregular wave-form. The most common forms of these instruments are the dynamometer-type instrument, the moving-iron or iron-vane type, the rectifier-type instrument and the thermocouple-type instrument. Of these, the moving-iron instrument need not be considered, since its current sensitivity is so low as to make it hardly usable in gaging applications. The dynamometer-type instrument is of greater value as a phase-sensitive instrument and will be so described.

Rectifier-type instruments for measuring alternating currents consist merely of d-c. instruments fitted with rectifying elements. The electrical connection employed in such an assembly may be any one of several forms, of which the most popular are drawn in Fig. 185. The simplest, at *A*, comprises a single half-wave rectifying element connected in series with the d-c. instrument. The rectifying element is represented by the arrow-head, which indicates the direction of current flow. At *B*, a full-wave arrangement comprising four rectifying elements (often called a rectifier bridge circuit) is shown, while *C* illustrates another full-wave arrangement employing two rectifying elements and two resistance elements. Of the three, the circuit at *A* is least expensive and least efficient; it has also the disadvantage of possessing much higher impedance to one half of the a-c. cycle than to the other. The full-wave arrangement at *B* is far more efficient, and permits current to flow during both halves of the cycle. The third connection, at *C*, is likewise more efficient than *A*, and has the further advantage that if the resistance elements are made variable, any change in impedance of the rectifying elements can be balanced, so that the effective impedance of the entire assembly is the same for both halves of the cycle. This is of considerable importance in some forms of bridge circuits, where it may be necessary to avoid producing any distortion of the excitation current wave-form. In these instruments the most popular rectifying elements are the dry-disk type (selenium or copper-oxide) although other types can also be used.

Thermocouple-type instruments depend upon the heating effect of the current being measured, and therefore are actuated only indirectly by the current being measured. In principle, these instruments all are connected according to some one of the diagrams of Fig. 127, although in practice somewhat more complicated arrangements are often used to increase sensitivity and provide freedom from undesirable temperature effects.

Thermocouple-type instruments are much less sensitive than rectifier-type, and suffer also from the disadvantage of a non-linear scale, greatly compressed near its low-current end. (This is just the reverse of what is needed for a satisfactory bridge-balance detector.) They are also easily damaged by overloads. Their advantages are that they are almost entirely unaffected by either wave-form or frequency.

and may thus be used at any frequency from zero to the radio frequencies. Rectifier-type instruments, although far more sensitive, and somewhat more accurate within their range, can hardly be used at frequencies outside the audible range—from perhaps 10 to 10,000 cycles per second. At higher frequencies the internal capacitances of the rectifying elements begin to disturb the operation of the instrument.

Less convenient in portable equipment, but occasionally used in conjunction with electron-tube amplifiers already installed, is the cathode-ray indicator tube, in common use as a tuning indicator or "magic eye" in household radio receivers. The device requires electric power for heating its cathode and for its plate current supply, and is relatively insensitive as well. It can be effectively applied as a phase-sensitive device, however, and will be described in that connection. It can be made to respond to any frequency employed in gaging practice.

§ 4. A-C. INSTRUMENTS: FREQUENCY-RESPONSIVE.

A more complex class of a-c. detecting and indicating instruments is the frequency-responsive group. These respond to the variations in current (or potential) while not necessarily reproducing faithfully the wave-form. The class includes instruments designed to be frequency-discriminatory, such as the tuned vibration galvanometer; but does not include the aperiodic or highly damped oscillograph galvanometers employed to record wave-form. These latter instruments constitute a special class.

Of the frequency-responsive instruments, the telephone receiver is probably the most widely used. This instrument (familiar in appearance to everyone) is in construction like the sketch in Fig. 186. A flexible diaphragm of mag-

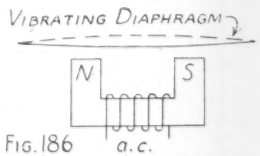


FIG. 186

netic material is stretched near the poles of a permanent magnet, upon which is wound a coil of wire. The attraction of the permanent magnet for the diaphragm is made less when current flows in one direction, and made greater when the current is reversed. Alternating current flowing through this coil will cause the diaphragm to vibrate, producing an audible sound. The telephone receiver is an extremely sensitive detector for alternating currents within the range

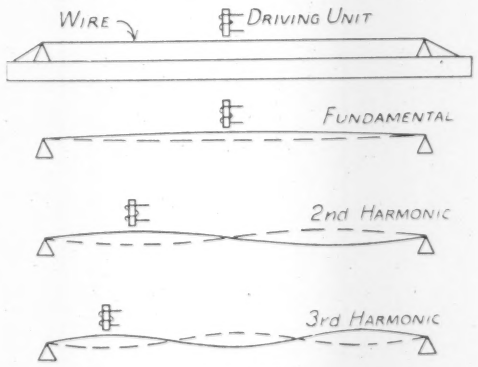


FIG. 187

of about 500 to 3,000 cycles per second, although not uniform in sensitivity throughout the range. Some mechanical tuning is possible.

Slightly more refined than the telephone receiver is the electrically-driven wire sonometer, which operates on the same principle. Instead of a diaphragm it employs a stretched steel wire, which is mechanically highly resonant. The instrument is therefore extremely selective in frequency response, since the wire will respond perceptibly only to its own natural frequency, or to harmonics of it. This ability to detect harmonics makes the vibrating-wire instrument especially valuable in vibration studies and in harmonic analysis. Fig. 187 illustrates the manner of construction of the instrument, and also the configuration of the wire for the first (or fundamental), second, and third harmonics. The position of the exciting coil (indicated) determines to which harmonic the instrument will respond.

The tuned vibration galvanometer is especially applicable to measurements in which it is desired that the detecting instrument be sensitive only to a particular frequency or to an extremely narrow range of frequencies. It is thus applicable to bridge circuits when there is doubt as to the purity of the exciting wave-form: the instrument simply ignores such impurities as may be present. Vibration galvanometers are made in both moving-coil and moving-magnet types, and are in construction similar to the d-c. galvanometers previously described. They differ, however, in being designed with mechanically-resonant moving elements and with quite high natural frequencies.

Fig. 188 shows the mode of construction for three of the most popular forms of a-c. galvanometers. Fig. 188A is similar to the moving-coil d'Arsonval galvanometer, but has both upper and lower suspensions made taut and supplying restoring torques. The suspended coil is thus made mechanically resonant. Fig. 188B represents a moving-magnet a-c. galvanometer, which comprises a small magnetized needle suspended within a magnetic field and also

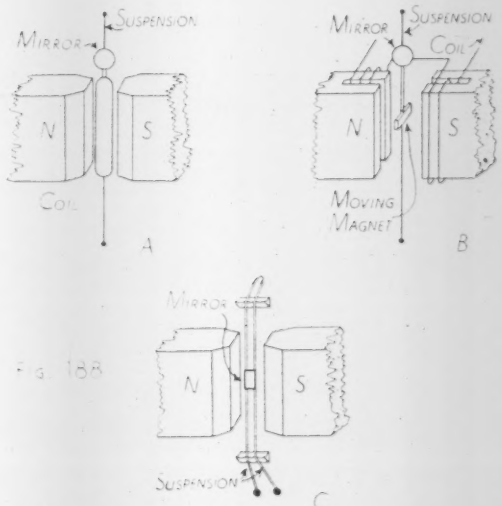


FIG. 188

within the field of a coil carrying the unknown current. The magnetized needle tends to orient itself opposing the field in which it is suspended; this field is the resultant of the permanent field and the field from the current coil. Fig. 188C illustrates another form of suspended moving-coil vibration galvanometer—the Duddell type. Here a single loop or "hairpin" is the moving element, and cemented between its two strands is a tiny mirror upon which a beam of light is directed. The reflected spot of light indicates upon a scale the amplitude of the vibration of the mirror.

It should be noted that galvanometers of these three forms can be used for oscillographic recording if suitably damped, or even for detecting direct currents.

Vibration galvanometers are far less sensitive than their direct-current counterparts, for two reasons: the dimensions of the coil limit the number of turns of wire it can contain and, since it is desirable to maintain a rather high natural frequency, the restoring force is made large.

The Einthoven or string-type galvanometer is sometimes used also as a vibration galvanometer; more often, however, it is used as an aperiodic oscillographic galvanometer.

With any of these instruments facilities are available for changing the natural frequency of the instrument within limits, to correspond to the frequency of the current being measured. The sensitivity of such an instrument at resonance is many times higher than at other frequencies; if the unknown current is not constant in frequency it is often desirable to introduce a sufficient amount of

damping to afford a good response curve. For general use, it is convenient to so adjust the damping that a change in frequency (from resonance) of 1% will reduce the sensitivity by 50%. Increase in amount of damping decreases the sensitivity of the instrument at the frequency of resonance, but makes its application easier, since small variations in frequency no longer cause large variations in amplitude of vibration.

These tuned and resonant detectors obtain their high sensitivity from the dynamic augment of the mechanical system. Because of their highly resonant condition, they cannot respond quickly to changes in amplitude, and are therefore not suitable for dynamic measurements. Their principal application is with null-method bridge circuits. Amplifying devices are often used with these instruments.

§ 5. Oscillographic Instruments.

Oscillographic instruments are those which are employed to delineate and to record wave-forms accurately and at high rates. Their outstanding characteristic is the ability to respond immediately and accurately to changes in magnitude of current flowing. Resonant behavior must therefore be avoided, and the natural frequency of the moving system must not fall within the range of frequencies to which the instrument is applied. Sufficient damping must be present to make the current sensitivity (the deflection per unit of current flowing) uniform throughout the range of frequencies to which it is applied.

It is apparent that the principal mechanical requirements for such an instrument are these two: the moving element must have small mass but relatively large restoring torque, so that its natural frequency may be made high; and the damping, whether electrical or mechanical, must be such as to make the response uniform with varying frequency. Since a small moment of inertia also is necessary to make possible a high natural frequency, most oscillographic instruments indicate and record with optical systems—massless pointers.

Probably the most popular oscillographic galvanometer in use at the present time is the electromagnetic type. These galvanometers are similar in construction to the vibration galvanometers of Fig. 188; they differ, however, in being heavily damped, so that instead of being mechanically resonant and therefore extremely sensitive at their natural frequency they are almost aperiodic and do not discriminate among frequencies in their operating range. Their effective operating range extends usually from zero to slightly less than half the undamped natural frequency.

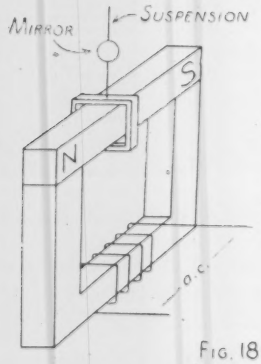


Fig. 189

Above this frequency there is usually some decrease in sensitivity. Through the use of an electric circuit known as a "resonant shunt" the upper limit of frequency response can be raised to nearly its undamped resonant frequency.

Another form of oscillographic element (not now often used, however) is the inductor-type galvanometer. It consists of a closed iron core carrying a current coil with a single movable loop of copper or aluminum encircling the core. This suspended loop must also be within a steady magnetic field. Current induced in this closed loop by the signal produces a field which reacts with the steady magnetic field to produce deflections of light-beam. The general form of the instrument is shown in Fig. 189. It is insensitive to direct current or to slowly changing currents; it is air-damped and—ordinarily—not very uniform in frequency response.

These magnetic galvanometers are made in a wide variety of styles and with a wide range of frequency response. Some are useful only at frequencies of less than 50 cycles per second, and produce a one-inch movement of the light-beam at a distance of one meter; others can respond to quite high frequencies (10,000 cycles per second has been attained). In order to raise the natural frequency of a galvanometer the restoring torque must be made large, so that high-frequency galvanometers may draw as much as an ampere of current per inch deflection. One popular model is satisfactory up to frequencies of about 800 cycles per second, and requires about 2.5 milliamperes of current to cause a deflection of one inch on a scale at one-meter distance. Other things being equal, the current required to cause a one-inch deflection with such a galvanometer increases approximately as the square of the upper limit of response frequency.

Dynamometer-type oscillographic galvanometers are also available; they can be used as wattmeters, or as phase-sensitive elements for other applications.

The cathode-ray oscillograph has within the last few years become widely used for recording extremely high frequencies. The device consists of an evacuated glass tube, one end coated with a luminescent material, the other fitted with an "electron gun," which ejects a small stream of electrons continuously toward the screen. Potentials are applied to a set of deflecting plates within the tube, causing the beam to deviate from its position of rest and to trace out on the screen a pattern representing the unknown wave-form; this pattern may be either observed visually (when the instrument is called an *oscilloscope*) or photographed for permanent record (in which case the device is usually called an *oscillograph*).

Most oscillographs are photographic; that is, they record on photographic paper. This method is advantageous in one respect—the optical levers employed have no mass, and therefore it is possible to keep the natural frequency of the instrument high. But photographic film or paper requires chemical development before it is available for examination, which is a decided disadvantage. In order to avoid the inconvenience and the delay entailed by the processing of the records, several instruments are now commercially available for producing oscillographic records in the form of ink lines on non-photographic paper. These are usually termed direct-writing oscillographs.

Direct-writing oscillographs are made with piezoelectric writing elements and with electromagnetic writing elements. The piezoelectric element usually employs a composite crystal assembly coupled by levers to a pen-arm; the electromagnetic element may operate as a moving-coil device or as a variable reluctance system. These devices (described there as generators) are sketched in Figs. 42 and 116.

§6. Phase-sensitive Devices.

During the last few years the great increase in the number of a-c. bridge circuits has stimulated the development of detecting devices having phase sensitivity as well as magnitude sensitivity. Because the output potential of an a-c. bridge circuit is shifted by 180 degrees when the adjustment is carried through balance, it is possible to take advantage of that fact in developing a detecting and indicating instrument for use with a-c. circuits. Such a phase-sensitive instrument can indicate both direction and magnitude of unbalance of a circuit; ordinary magnitude-sensitive instruments do not possess this ability.

When the mirror of a vibration galvanometer is illuminated by stroboscopic pulses of light excited by the frequency being measured, the pattern produced is a single dot, instead of an extended trace. The position of this dot is a measure of the phase angle between the unknown current and the pulses of light. It is therefore possible to employ an ordinary vibration galvanometer as a phase-sensitive instrument by replacing the constant light source

(Continued on page 560)

APPLICATIONS OPERATING PRINCIPLES INSTALLATION MAINTENANCE

Aviation Instruments

Navigation Automatic-piloting Power plant Automatic-landing Aerological
Communication Flight-testing Production Instrument-testing

Vol. IV, No. 8 M. F. Béhar, Editor August 1945

Aerial view of the Liberty ship on which is based the First Aircraft Repair Unit (Floating) with helicopter, on flight deck, preparing to take of. *(Photo by Air Technical Service Command)*

Floating Depots Equipped for Aircraft Instrument Repair

By Captain HARRY B. GILSTRAP, ATSC, Wright Field, Dayton, Ohio

COMPLETE overhaul of aircraft instruments is being performed at sea in Liberty ships converted by Air Technical Service Command into floating B-29 repair shops, as well as in conventional AAF installations ashore. A number of these vessels are anchored off the reef-choked waters of the Marianas, where they perform "fourth echelon" maintenance of instruments and other aircraft accessories and parts, requiring special tools and personnel with advanced training.

The 440-foot Liberty ships are fitted with air-conditioned shops for the repair of electrical, mechanical, and optical instruments, bombsights, and the automatic pilot. There are also facilities for work on propellers, carburetors, turbo-superchargers, electrical equipment, sheet metal, fuel cells, tires, and other components of the giant Superfortresses. The ships were equipped with the Boeing B-29 in mind, but can also perform work for all other models.

Purpose is to provide fourth-echelon maintenance as soon as air strips in a newly-taken area have been completed, thus saving the two-to-six-month period normally required to set up comparable installations ashore. When shore installations are functioning fully, the "Aircraft Repair Units (Floating)," which is the formal name of the new organizations, may haul up anchor and proceed to a more advanced destination, where they can perform their mission all over again.

An unusual feature of the floating air depots is the flight deck, which is perched above the forward portion of the main deck, from which helicopters operate. These rotary-wing craft, part of the vessels' equipment, fly key personnel, small parts, and small tools between ship and shore. They have been especially useful in flying critical instruments to B-29's which would otherwise have been grounded for lack of them. The vessels also carry DUKWs ("ducks"), jeeps with trailers, and work-boats along with them; these are swung over the ship's side by booms when required.

The instrument shop is set up for the complete overhaul of the following: altimeters, gyro flux compasses, sextants, driftmeters, astro compasses, tachometers, bank and turn indicators, rate-of-climb indicators, ammeters, voltmeters,

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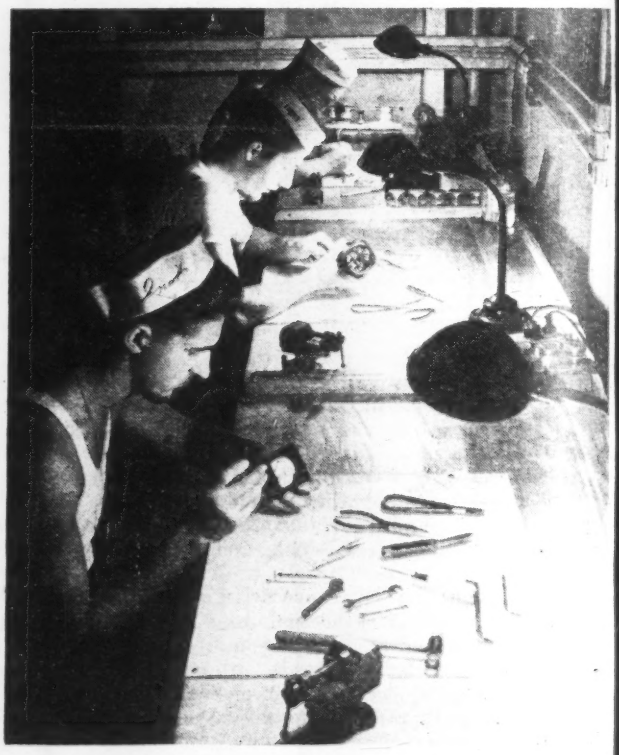
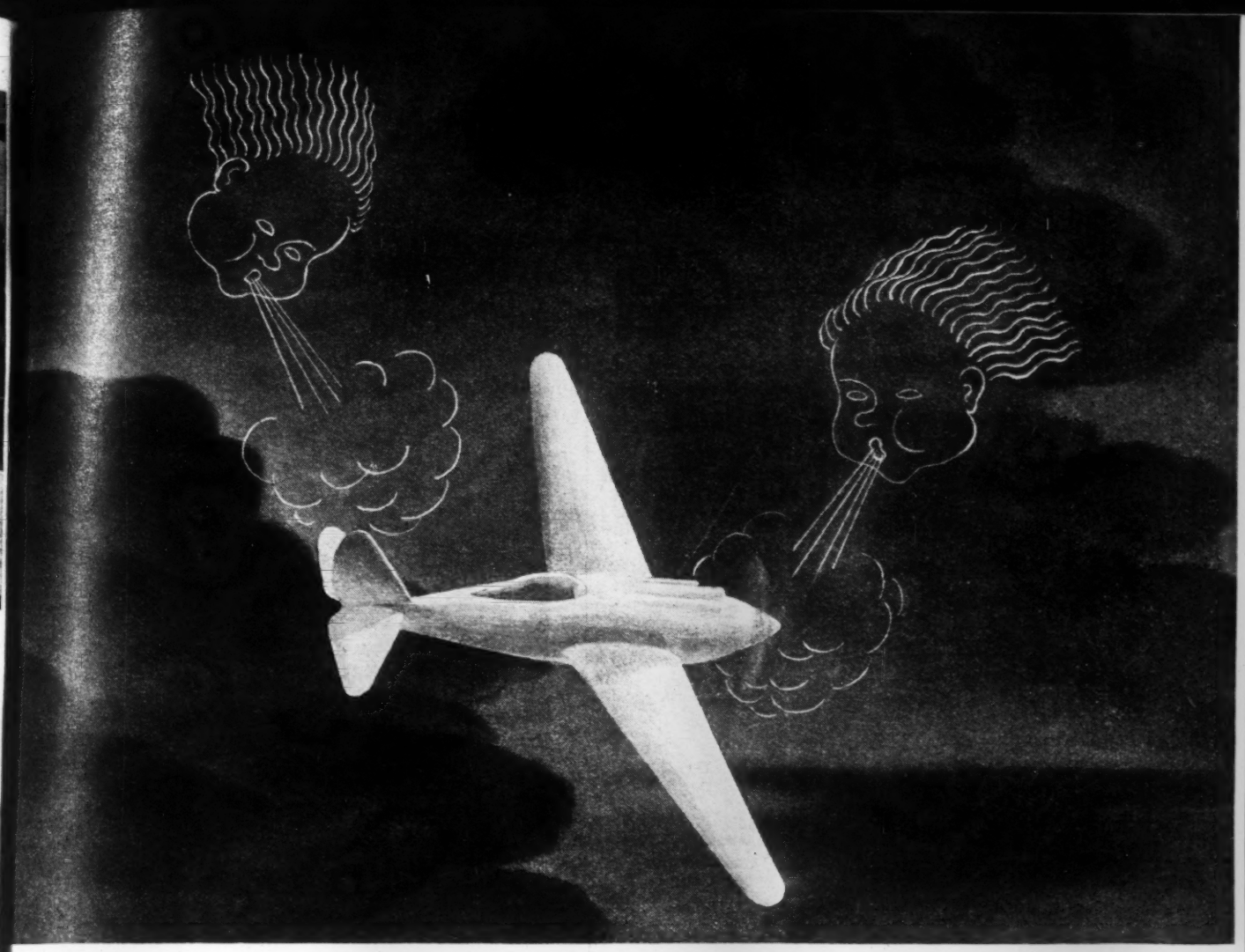
Facilities for the repair of watches, so necessary for precision aerial operations are to be found aboard the Liberty ship in which the First Aircraft Repair Unit (Floating) performs its work. Unit provides "fourth echelon" maintenance for aircraft until permanent facilities can be set up; then it pulls up anchor and moves ahead to the next base. Watchmaker shown here is Cpl. Charles R. Drewery, 1402 North Henderson Rd., Rusk, Texas, who received training for his job from Air Technical Service Command.

manifold pressure indicators, fuel and oil gages, all Autosyn instruments, various types of thermometers, fuel and oil level gages, suction gages, landing gear hydraulic pressure gages, watches, clocks, flap position indicators, and other instruments.

Minor repair, checking, and partial overhaul of bomb-



Left to right: Pvt. Henry A. Zielinski, Brooklyn, working on an ammeter; Cpl. James T. McCord, Sr., Nashville, Tenn., repairing a gage indicating engine temperature, and fuel and oil pressure; and Cpl. Charles R. Drewery, Rusk, Texas, who is fixing an aviator's watch. *(Photos by Air Technical Service Command)*



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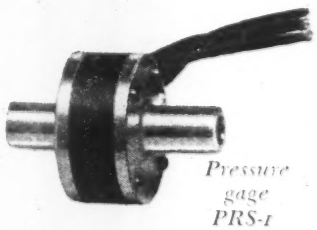

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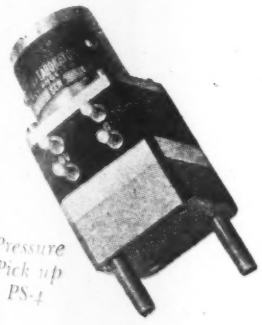

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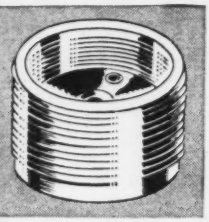

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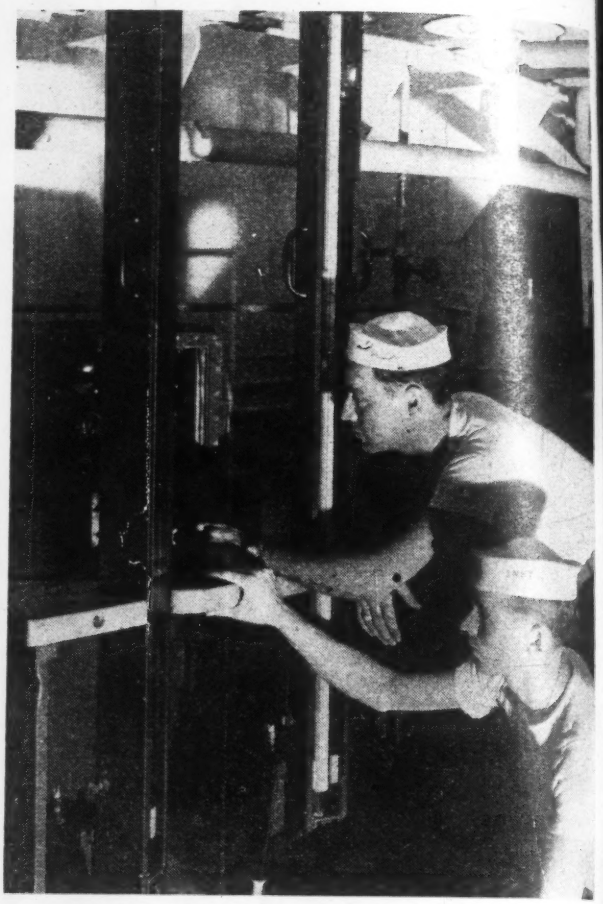

Manometer on shipboard is used to test air-operated instruments in a Liberty ship converted by Air Technical Service Command into a sea-going B-29 repair shop. Ship is presently speeding Superfort operations against the Jap mainland by helping to keep aircraft instruments in tip-top shape. Left to right: T/Sgt. Irvin L. Sebransky, instrument shop foreman, and Sgt. Keith N. Lowery, his assistant. Like their fellow-mechanics on these floating air depots, these men wear sailor hats and dungarees.

sights, Automatic Flight Control Equipment, directional gyros, artificial horizons, and the new air position indicators is also accomplished.

Personnel in the instrument shop of one of the most effective of the sea-going aid depots, the first Aircraft Repair Unit (Floating), is under the direction of T/Sgt Irvin L. Sebransky, of Cleveland, who spent three years in the Caribbean before the army gave him his present assignment. Instrument work was his specialty there. All men in the shop are highly trained, and were sent to special schools in their particular lines by Air Technical Service Command before leaving for the Pacific. Some like Cpl. Charles R. Drewery, of Rusk, Tex., were watchmakers before they entered the service. Sgt. Howard R. Bancroft, who inspects instruments repaired aboard the vessel before they are forwarded to using activities, was employed by Sperry Company before the war.

It was found, when the ship reached its destination, that some of the finer precision work could not be accomplished at sea, even when the ship was in a quiet anchorage, and an auxiliary shop was therefore set up ashore to handle such jobs. Most of the work, however, is done aboard the vessel.

The shop is well equipped for its task, having, among other things: two single-tube well-type manometers with ranges of 61 inches of mercury and water; a portable vacuum pump; an electrical instrument test panel; a 110-volt single-phase 60-cycle laboratory lathe; a ¼ inch capacity single-phase 60-cycle super-sensitive drill press; two oil and moisture separators; one motor-driven turn table assembly to test bank and turn indicators; a jeweler's lathe

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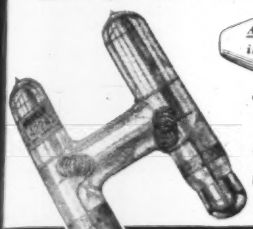

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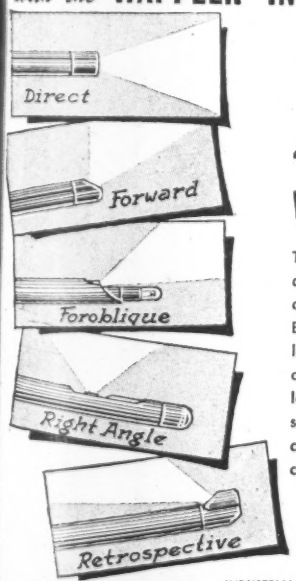

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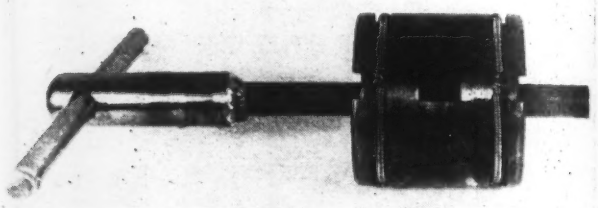
Sgt. Sebransky estimates that the shop's production is 350 instruments of all types per month.

Air Technical Service Command, after the careful selection of personnel, sent the members of the outfits to a marine training school in Fairhope, Ala., where maritime nomenclature, abandon-ship procedure, and related subjects were taught. Men in the repair units call themselves "sailjers," wear dungarees and white sailor hats, and are as at home at sea as they are in the air or on land.

Two Sergeants Invent Device for Installing Field Coil Assemblies in Aircraft Starters

WASHINGTON—Believing the old adage that two heads are better than one, Technical Sergeant James W. Turner of East Point, Ga., and Staff Sergeant Levere M. Holmes of Ogden, Utah, recently pooled their ideas and mechanical



Field coil pole-shoe expander devised and constructed by Technical Sgt. James W. Turner of East Point, Ga., and Staff Sgt. Levere M. Holmes of Ogden, Utah, enables soldier-technicians at an Air Service Command depot in England, to install new field coils in repaired airplane starter motors at eight times the rate formerly possible.

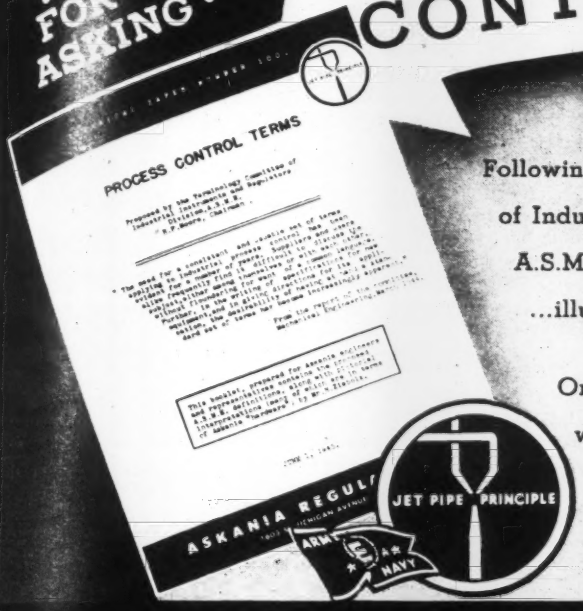
ability and constructed a device which in addition to being a tool and labor-saver, reduces the time for installing a new field coil assembly in an overhauled aircraft starter from three quarters of an hour to only five minutes.

Soldier technicians at their Air Service Command depot, in England, at one time fitted the assembly into the motor housing section of the starter with the use of only a press

Soldier-technicians at an Air Service Command depot in England are now installing as many new field coils in airplane starter motors in one day as was formerly possible in eight with an expander constructed by Technical Sergeant James W. Turner (left), of East Point, Ga., and Staff Sergeant Levere M. Holmes of Ogden, Utah. Sergeant Turner is shown fitting a new field coil in the motor housing with the expander as Sergeant Holmes assists.

Yours FOR THE ASKING...

A DICTIONARY OF TERMINOLOGY REFERRING TO VARIOUS TYPES OF CONTROL EQUIPMENT



Following the work done by the Terminology Committee of Industrial Instruments and Regulators Division of the A.S.M.E., we have published this terminology dictionary ...illustrated by Mr. Herbert Ziebolz's free-hand sketches.

Originally published only for our own organization, this work has proved so helpful and interesting to control engineers, that we have secured a sufficient quantity for a limited distribution. Write for your Free copy today!

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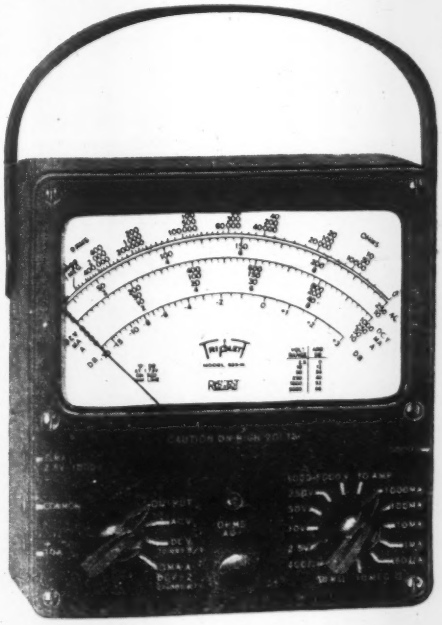

Long Scale, Wide Range Volt-Ohm-Milliammeter

DOUBLE SENSITIVITY D.C. VOLT RANGES

0-1.25-5-25-125-500-2500 Volts, at 20,000 ohms per volt for greater accuracy on Television and other high resistance D.C. circuits.

0-2.5-10-50-250-1000-5000 Volts, at 10,000 ohms per volt.

A.C. VOLT RANGES

0-2.5-10-50-250-1000-5000 Volts, at 10,000 ohms per volt.

OHM—MEGOHMS

0-400 ohms (60 ohms center scale)
0-50,000 ohms (300 ohms center scale)

DIRECT READING OUTPUT LEVEL DECIBEL RANGES

—30 to +3, +15, +29 +43, +55, +69 DB

TEMPERATURE COMPENSATED CIRCUIT FOR ALL CURRENT RANGES D.C. MICRO-AMPERES

0-50 Microamperes, at 250 M.V.

D.C. MILLIAMPERES

0-1-10-100-1000 Milliamperes, at 250 M.V.

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0-10 Amperes, at 250 M.V.

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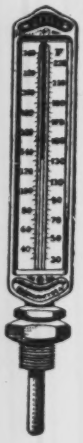

PRECISION INSTRUMENTS

INDUSTRIAL THERMOMETERS
LABORATORY THERMOMETERS
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THERMOSTATS
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Extreme Precision Grade: Solid glass etched stem, mercury thermometers (nitrogen filled) for determining temperatures within a fractional part of a degree.

Standard Thermometers: Provide laboratory accuracy combined with sturdiness. Made of highest grade glass and materials. Mercury filled, calibrated for total or partial immersion. Types with "Moeller Glass Red Reading Column" afford optimum ease in reading.

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screwdriver. Countless screwdriver bits were broken in the process, resulting in the loss of productive man-hours and eventually causing a critical shortage of these tools.

When the flow of starters, in need of repair, threatened to dispossess Sgt. Turner from his shop, he consulted with Sgt. Holmes and soon after the first field coil pole-shoe expander made its appearance at the depot.

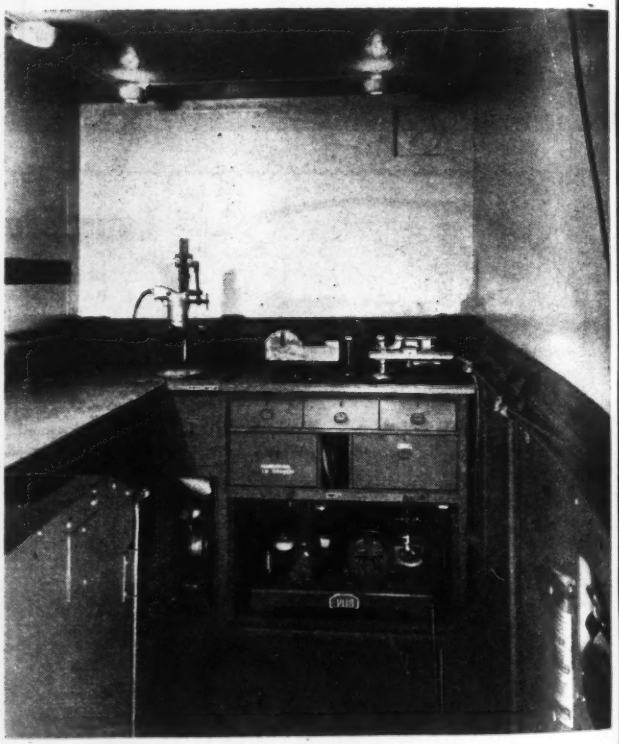
It consists of two conical shaped pieces of steel which are rimmed with four sections of metal and screwed on a shaft threaded with both left and right hand threads. As the shaft is turned to the left the steel cones move in opposite directions and expand the outer rim pressing it against the coil assembly and pole-shoes thus making it a simple affair to insert the armature after the expander has been removed.

The use of the device has increased the production of repaired starter motors at the depot to a point where as many new field coils are installed in one day as was formerly possible in eight.

Portable Workshops Speed Repair of Bomb and Computing Sights

TOLEDO, Ohio.—Air-conditioned light-weight collapsible workshops that can be transported by air and set up at advance bases are being employed by the Army Air Forces for the adjustment and repair of bomb sights and computing sights.

Equipped with precision tools, the shops enable skilled AAF mechanics to do the work on the spot, saving the time



that would be required to send the instruments to rear bases. Glass fibers, compressed, treated with a resin, and shaped into flexible boards, are employed as insulation needed to help assure the required control of temperature and humidity within the shops. The inorganic Fiberglas insulation stands up against the attack of fungi encountered in Pacific war zones, and is incombustible. Its light weight is an important factor in making practicable air transportation of the shops.

The shops are built by the Herman Body Company, St. Louis, for the Materiel Command, Army Air Forces, Wright Field. Insulation is supplied by Owens-Corning Fiberglas Corporation, Toledo.

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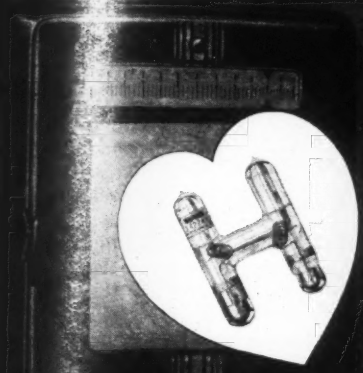

No matter how perfect otherwise, the human organism isn't much good without a dependable heart. The same is true of your automatic temperature and pH control instruments.

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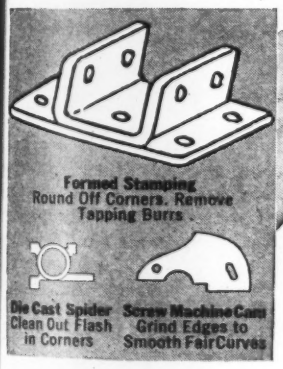

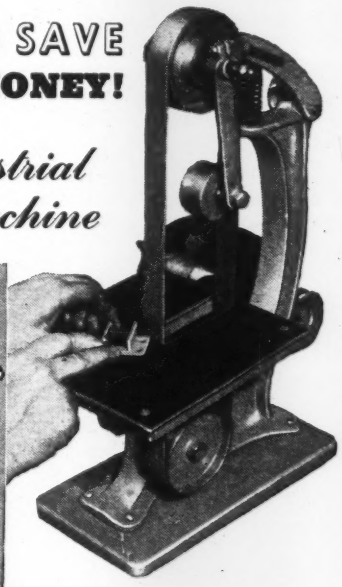

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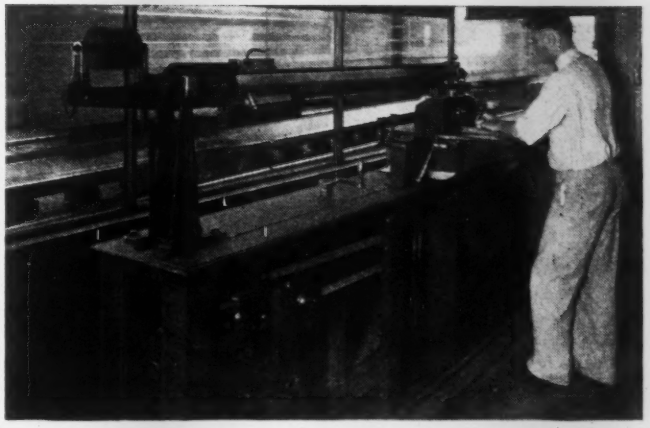

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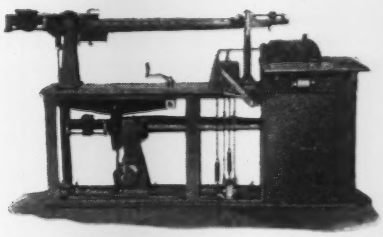

Type NT Automatic Weight Recorder. Automatically prints weights of cars in motion. May be attached to any railway track scale. No capital investment.

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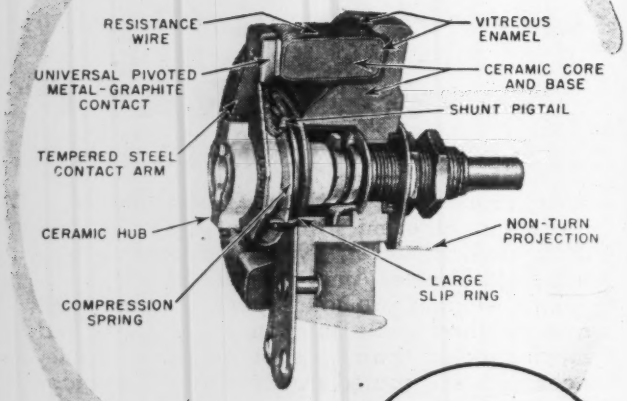

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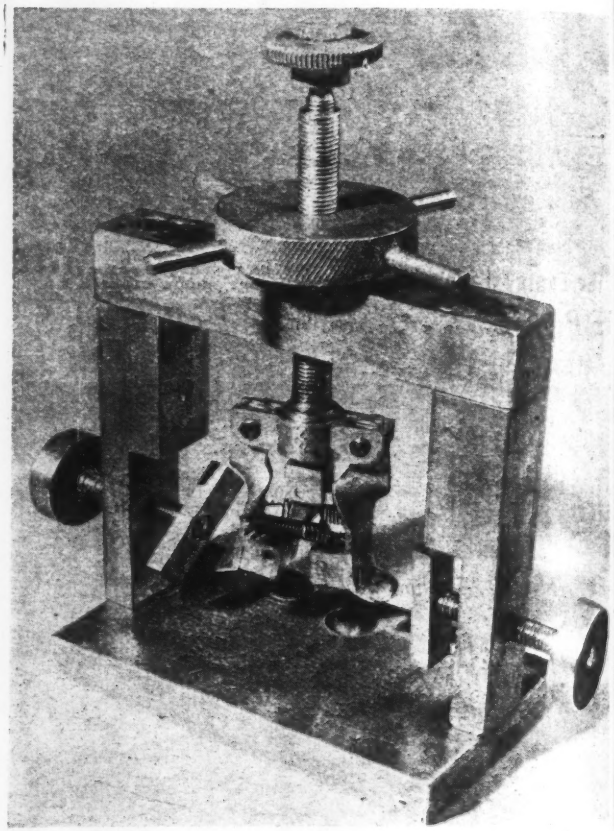
Device to Remove Retainer Rings or Bezels from Instrument Cases

By JOHN S. BOTTIMORE, Jr., Norfolk, Va.

THIS device is used to remove retainer rings from instrument cases without damage either to the case or the glass. The case is mounted on the base and the puller is run down into a position just above the glass. To find the center of the case, the knobs of the small oblong blocks are turned until the case flange is snug, then a little manipulation on the turning of the knobs places the case in the center of the puller. The wheel at the top is turned, forcing the two puller arms apart and under the retainer ring at such an angle and pressure as to not injure the case or the glass.



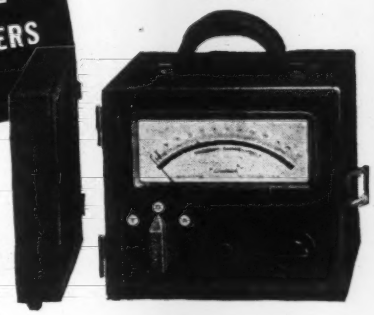
Then the large handle is turned to start the retainer ring. After starting the ring removal a new purchase may be adjusted by turning the screw shaft at right angles to the original pulling position. The springs between the puller arms keep the tension on the arms and permit easy release of the ring when desired. Holes are drilled in the base to fit the instrument zero adjuster on the case or any protrusion such as a push button.

Construction Details

The screw which is attached to the puller arms is drilled inside and tapped from the top to a depth of ¾". A shaft goes through the length of the pulling screw and is fastened to a hinged box. This shaft has an inch of thread to correspond with the inside tapped thread. Thus, a turn of the inside rod creates a downward force transmitted to the hinged puller arms, spreading them. The large wheel is turned in one piece in making it with a sleeve which is bradded against the bottom of the cross-bar holding the wheel securely to the bar. To reduce surface friction, a small bushing is used as a spacer between the wheel and the

Alnor
RESISTANCE THERMOMETERS

Type 2900
Portable Resistance Thermometer



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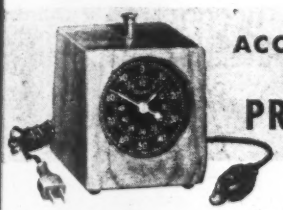

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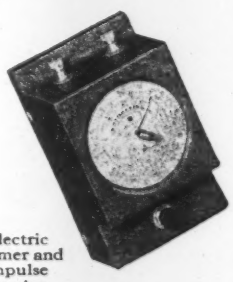

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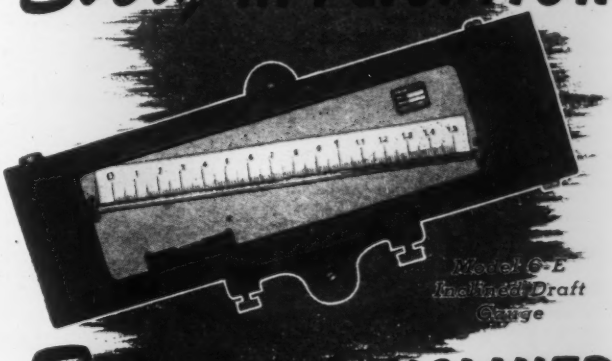

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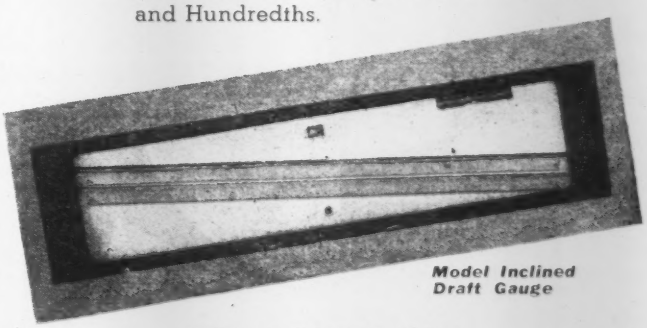

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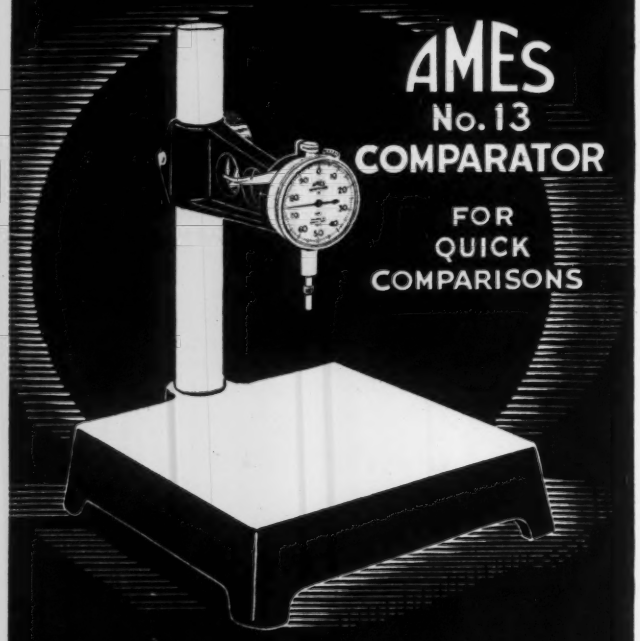

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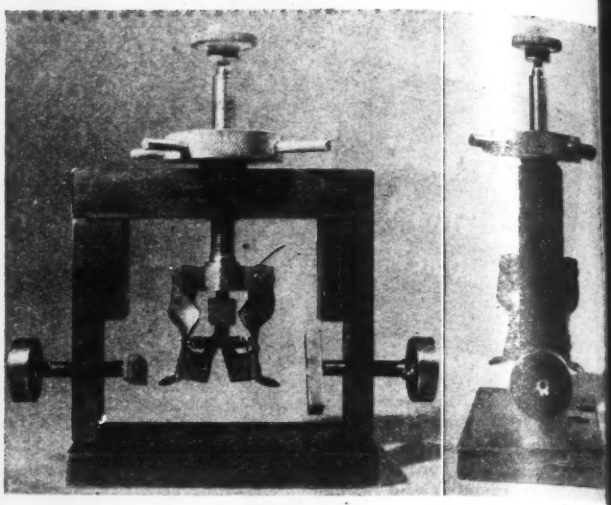

crossbar. All threads are 28. The base is aluminum, the frame cast iron and the puller arms tool steel, silver soldered to the small hinge blocks.

Overall width is 4⅜", heighth from the base to the top of the crossbar is 4⅝", and the length of the pulling screw thread is 3". This device will accommodate case up to 3½".

This device is now being used in the United States Naval Air Station Instrument Shop, Norfolk, Virginia, on such instruments as voltmeters, ammeters, and the like, to remove either retainer rings or inside magnetic shields.

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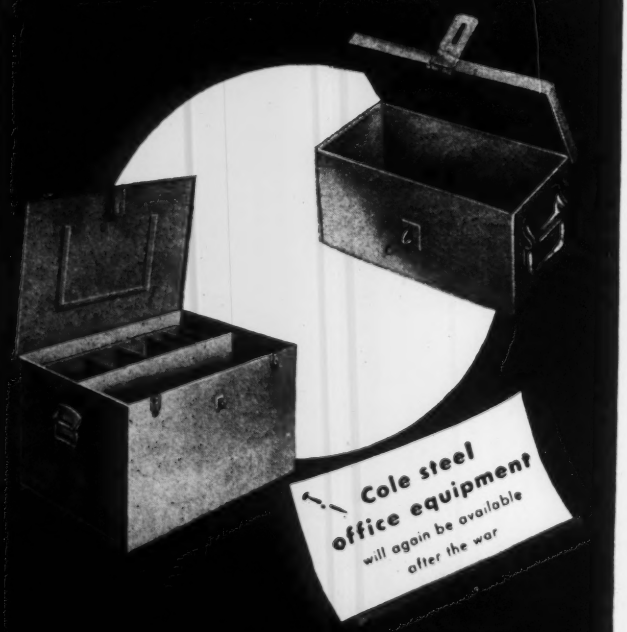

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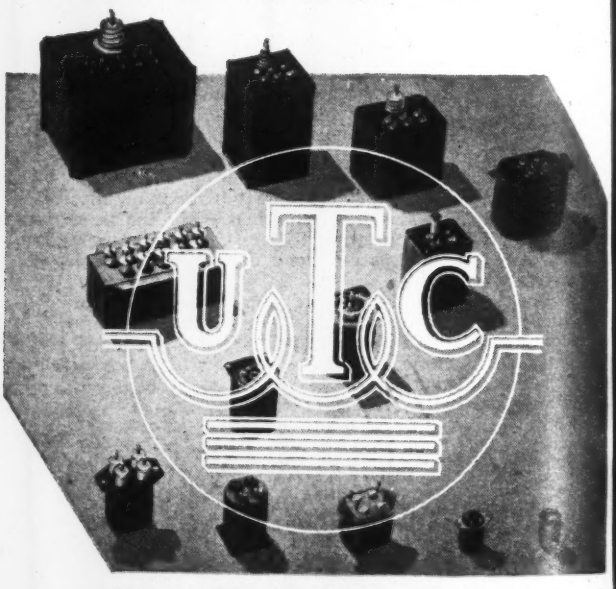

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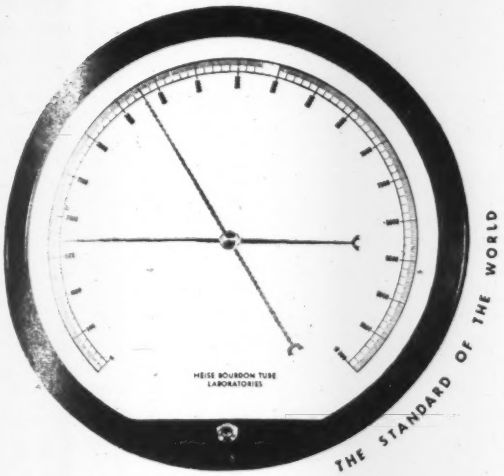

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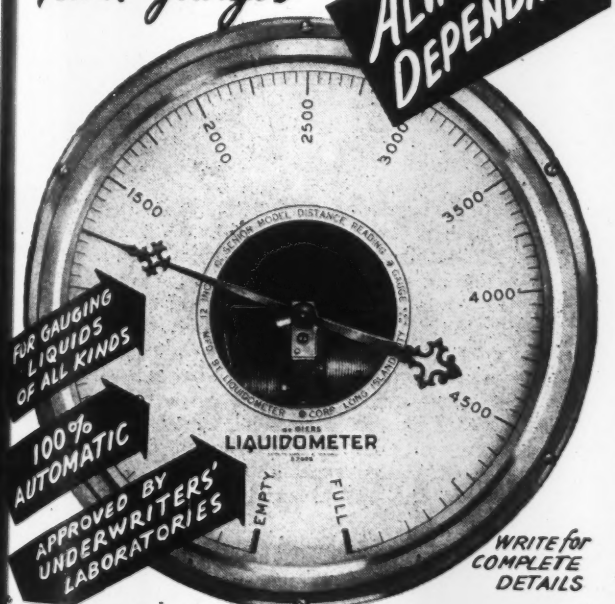

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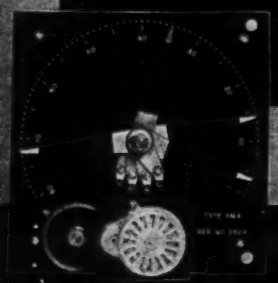

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(Continued from page 544)

by a neon bulb, strobotron, or other timed intermittent source. The method is especially well suited to circuits in which the a-c. excitation is produced by a rotating commutator, since then the pulses of light can be produced by a shutter mechanically coupled to the commutator.

Phase-sensitivity is of course available by the use of indicating instruments of the dynamometer type. In these, the output current from the bridge circuit is applied to one set of coils, while the other coils are actuated by the exciting current. When the currents in the two coils are alike in phase, their fields oppose and repel, and the instrument pointer will deflect in one direction—when the currents differ in phase, the coils attract and the direction is reversed. Again the instruments can indicate direction of unbalance as well as magnitude.

The use of the tuning indicator or "magic eye" as a phase-sensitive device is well established. In this circuit, Fig. 190, two such tubes are employed. The output potential of the bridge is applied to the control grids of both tubes; at the same time the a-c. excitation potential of the

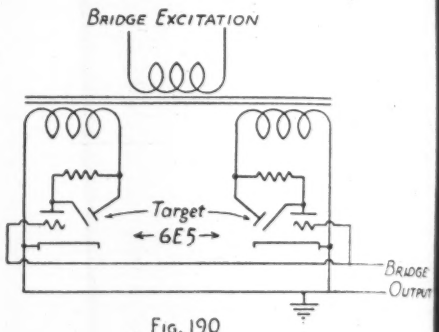

Fig. 190

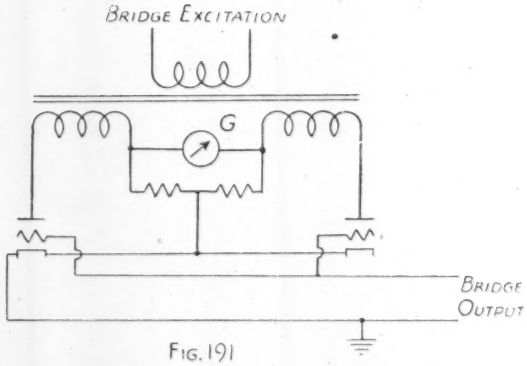

Fig. 191

circuits is applied to the plates of the tubes. Current can flow through such a tube only when the anode potential is higher than the cathode potential and when also the control grid is at a higher potential than the cathode. If current is to flow, the control grid and the anode must be of the same polarity. Both anodes are supplied with the same alternating current used to excite the bridge circuit; by means of a transformer the current reaching one plate is made 180 degrees out of phase with respect to the other; only one tube can conduct at a time. Since the size of the pattern appearing on the fluorescent screen of the indicator tube depends upon the current flowing, it is easy to ascertain the phase of the output—and the approximate magnitude.

The same type of phase-sensitive electronic detector, fitted with an indicating instrument instead of two "tuning eye" tubes, is shown in Fig. 191. It is usually called the Cosens Locking-in Amplifier.

Devices having phase sensitivity and employing other types of rectifying elements are also available. Four characteristic forms, ordinarily used with dry-disk rectifiers will be described.

In the first of these, shown in Fig. 192, a half-wave recti-

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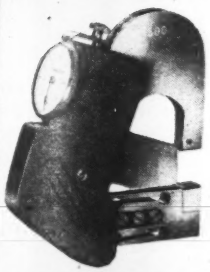

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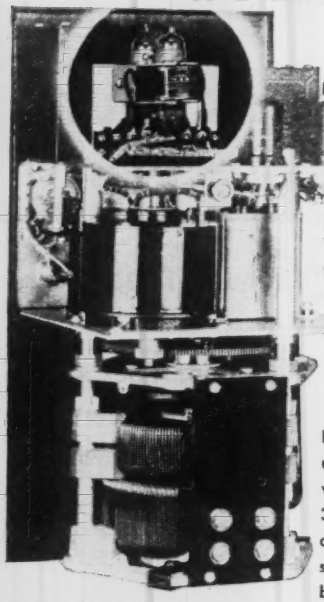

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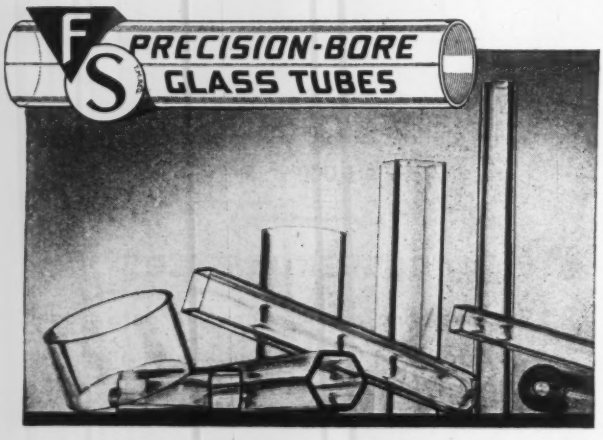

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fying element has been inserted in each of two arms of the bridge circuit. The circuit is not so efficient as some other It has been found desirable to introduce two more rectifying elements (dotted connections in drawing) so that rectification occurs during both halves of the cycle. Distortion in the exciting wave-form can cause inconvenience in operation; the second pair of rectifiers eliminates this.

The circuit just described (Fig. 192) has the disadvantage that the rectifier elements appear in series with two

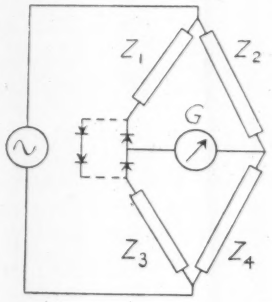


FIG. 192

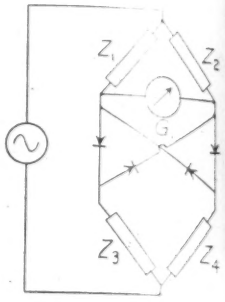


FIG. 193

measuring arms of the bridge circuit itself; they may be in series with the values being measured, and error will be introduced unless the resistance of the bridge circuit is high—so high as to make the rectifier resistance negligible.

Another circuit, likewise having rectifying elements within the bridge-circuit arms, is drawn as Fig. 193. This is one of the most efficient circuits of this type; it also suffers from inaccuracy due to the presence of the rectifiers within the bridge circuit, unless the impedances are high compared to the rectifiers.

Two other circuits affording phase-sensitivity, but not having non-linear elements inside the bridge circuit, are shown as Fig. 194. The operation of these circuits depends upon the presence of a "polarizing" potential applied to the rectifying elements. This potential (about one volt in magnitude) when applied across a copper-oxide rectifier, causes it to conduct (and to rectify) if the polarizing potential is in phase with the bridge-circuit output, but does not permit

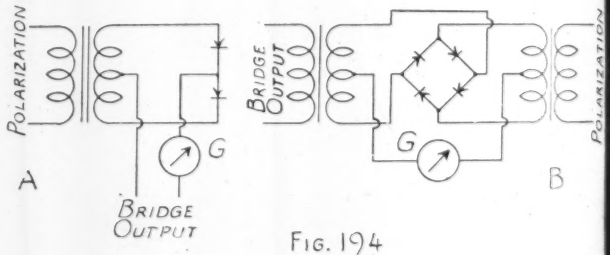


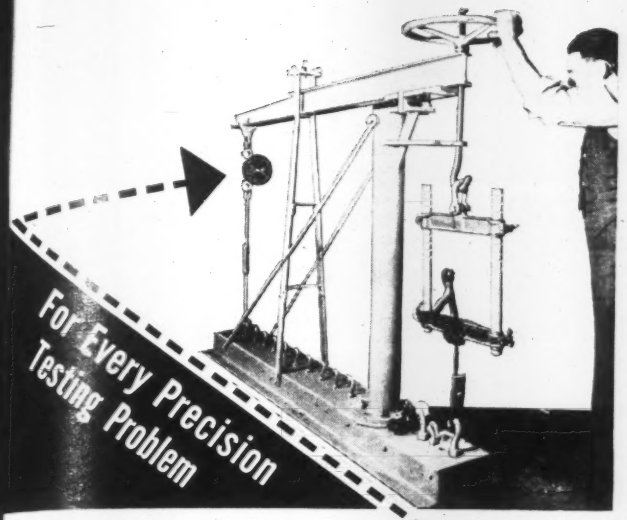
FIG. 194

current to flow if the potentials oppose each other. It is this action which provides the phase-sensitivity. Fig. 194A illustrates a half-wave form of this circuit, and a full-wave circuit is shown in Fig. 194B. Both circuits have been effectively used.

These phase-sensitive circuits add greatly to the convenience of operation of an a-c. bridge circuit. In certain types of measurements they make available actions of the bridge circuit which cannot be obtained in any other manner. For example, it is possible to adjust the circuit to permit changes in reactance without affecting the indication of resistance balance—and, of course, the converse. Their principal disadvantage is the need for supplying the polarizing voltage and occasionally for adjusting its phase.

In many present-day gaging applications phase-sensitive rectifiers are used. Electron-tube amplifiers may conveniently be used to increase the system's sensitivity, and the current-measuring instrument may be an ordinary d-c. milliammeter. For dynamic work, the circuits are applied to electromagnetic galvanometers.

(To be continued)



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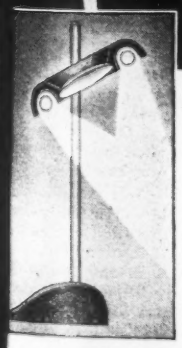

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MINIMIZING REFLECTANCE

(Continued from page 536)

ample. A common type lens has five elements, only two surfaces of which are cemented together. Of the eight remaining surfaces, each costs the system up to 4% of the light supplied it, resulting in a total loss of nearly 30% of the light. When dealing with fast action and limited light as in war photographs or measurement technique such as light speed action—stopping, or movie film work, a terrific loss such as represented by an untreated lens may spell the loss of a most necessary picture.

Commercial television depends upon a clear image at the end of an oscilloscope tube. This can be badly spoiled if light reflections from the end of the tube interfere. The same applies throughout the television system from the pick-up of the image to the final projection in the home. With measurement technique such as used in profilometers, radar, optical projection, under-water sound, panoramic radio reception, aerial and surface craft navigation—all of which use optical systems similar to television—the gain in image clarity demands lens treatment. This treatment can be applied to x-ray, ultra-violet and infra-red apparatus and even to metal windows used for transmission of radiations.

So far only image r[e]duction ha[s] been mentioned, but a[n] with movi[e] equipment where a 25% [l]n in scree[n] illumination was obtaine[d] the econom[y] ic factor is important. On[e] oy lantern railroad signals, street la[m]s and auto mobile signals, economica[l] and visual ly a lens treatment is de[s]able. With such prospects, doesn't th[e] instrumen[t] user or maker need t[o] investigat[e] further?

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EDITOR'S ADDENDUM.—The following would have been included by Lt. Co[l]. Selo[n]stad, we believe, if he had known [o]f it. We have just learned about it in the [c]ourse of corresponding about the illustrations for this article: A. F. Turner. "Anti-[R]eflection Films on Glass," *The Educational Focus* (Bausch & Lomb Optical Co., Rochester, N. Y.), Vol. XII, Spring 1941 Issue, pages 4-11. We heartily recommend this article to non-mathematical readers.—M.F.H.

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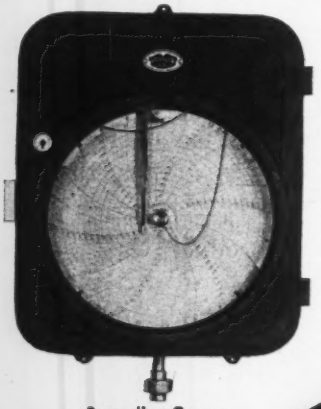

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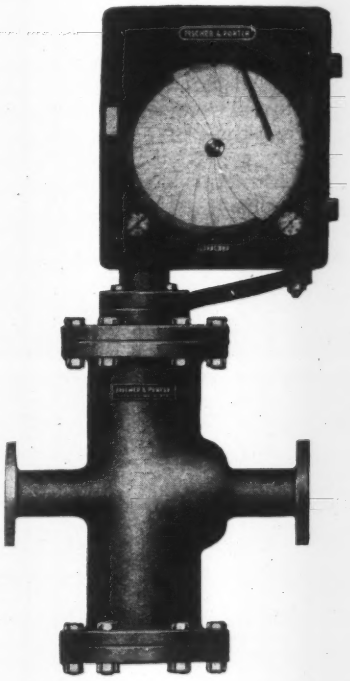

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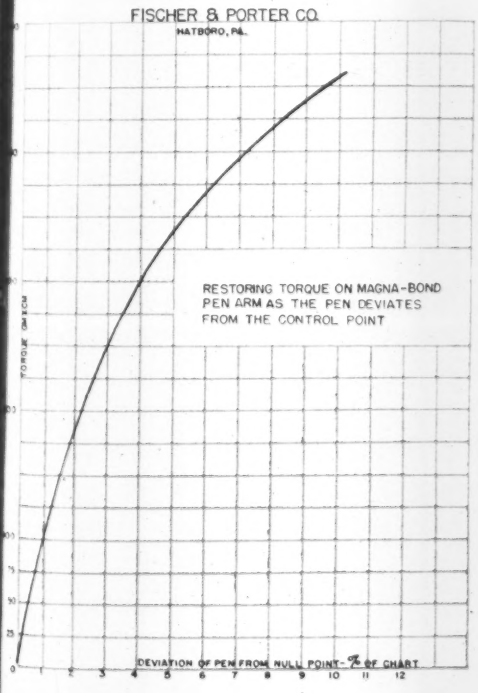
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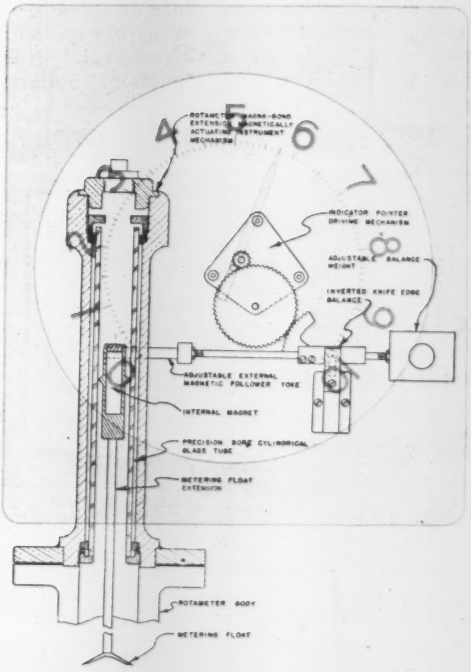

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Curtiss-Wright Wind Tunnel

(Continued from page 537)

tight, and the two tunnel doors of the test chamber are opened by remote control. The test chamber is now merely a section of the tunnel.

Two adjustments by the tunnel control operator are now required. First, he sets a switch which determines whether the pressure system or the vacuum system is to operate; second, he sets the control pointer of the Foxboro instrument for the desired static pressure. From here on, control is automatic. A pressure switch in the static pressure tap from the tunnel to the pneumatic controller automatically determines which of the two bleed valves the instrument is to control. The deciding point, arbitrarily set, is at 20 lbs./in.^{2} gage pressure. If the static pressure is to be above 20 lbs., the 4″ bleed valve is used. For pressures below 20 lbs., and including the entire vacuum range, the 6″ bleed valve is under instrument control.

The use of these two alternative bleed valves, according to the density of the atmosphere within the tunnel, facilitates the precise control of static pressure at the desired point and the relief of excess pressure at a gradual and known rate of flow. The same valves function, similarly but in a reverse direction, when there is partial vacuum instead of static pressure in the tunnel.

Instead of two control instrument installations, one for pressure service and one for vacuum, one Foxboro controller was made to do the work of two, by means of a pneumatically-operated three-way valve, which automatically reverses the impulse from the air relay and therefore the action of the control valves, when tests are being made under conditions of partial vacuum. In short, any condition of pressure or vacuum within the measuring range of the instrument is also automatically under instrument control, and the instrument adjusts itself to become a pressure controller or a vacuum controller, according to the setting of the control point.

At the conclusion of a test, the test chamber is locked off from the tunnel and its air content brought to atmospheric pressure, so that workmen and observers may safely enter. The control of the three air-tight doors is a feature of importance in the tunnel design. It is provided by two Foxboro "Rotax" differential pressure controllers, so installed as to measure the differential between the air pressure within the test chamber and within the rest of the tunnel, and also the differential between chamber pressure and the outside atmosphere. The "Rotax" controllers, having a number of electric contact circuits which, through relays and solenoid valves operate large equipment electrically, keep the chamber doors securely closed whenever the tunnel is in operation and the measured differential is greater than ¼″ of water, or approximately 0.01 lb./in.^{2}

From the safety viewpoint, the importance of this installation is obvious. Automatic control of the air-tight doors prevents any accidental opening of them, which might cause disaster through explosion or implosion, or serious "bends" injury to personnel.

Safety is further assured in the engineering of the instrumentation at Curtiss-Wright. All instruments are designed to "fail safe"; that is, in case of failure of the air supply for the tunnel pressure controller, the bleed valves will open; and if any of the "Rotax" controller's electric circuits should burn out or fail, the chamber doors will remain closed.

In addition to the prime factor of safety, operating economy is an important consideration in the instrumentation of the wind-tunnel. Normally two to three hours' operation is required for the compressors to raise air pressure within the tunnel from atmosphere to 60 lbs./in.^{2}. In valuable time, as well as in electric power, the expense is considerable. But, with air-tight doors to the test chamber, only that air which is within the chamber is relieved, while conditions in the rest of the tunnel are held as they were during the test. By the appropriate scheduling of successive tests, the maximum use can be made of tunnel conditions.

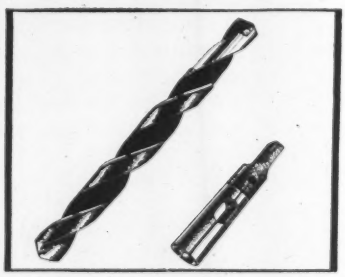
New Shankless Roll-Forged Drill is Faster, Tougher, More Economical

Developed by Ford for wartime uses—available now to industry in general. "More holes at less cost," is the claim for this ingenious new Shankless high speed drill—made in two parts—the drill itself, and a removable taper shank, known as the "drill driver." By this separation, costs to the user have been cut 20% to 30% under conventional taper-shank drills. In the conventional drill, the shank must be discarded when the point and flutes are worn out. Here, however, the drill driver is used throughout the lives of many drills. Shankless drills are roll-forged and twisted, unlike the machined manufacture of ordinary drills, for improved structure.

Principal advantages are (1) Lower first cost. (2) Greater hole production because of greater strength. (3) Reduced breakage with tough "shock-absorber" neck. (4) Greater length of usable flute. (5) Greater scrap recovery value of unused portion of drill.

Wartime advantages of Wrigley's Spearmint Gum show how this quality product, too, can help industry—once it again becomes available. In the meantime, no Wrigley's Spearmint Gum is being made; and none will be made, until conditions permit its manufacture in quality and quantity for everyone. That is why we ask you to "remember the Wrigley's Spearmint wrapper," as the symbol of top quality and flavor—*that will be back!*

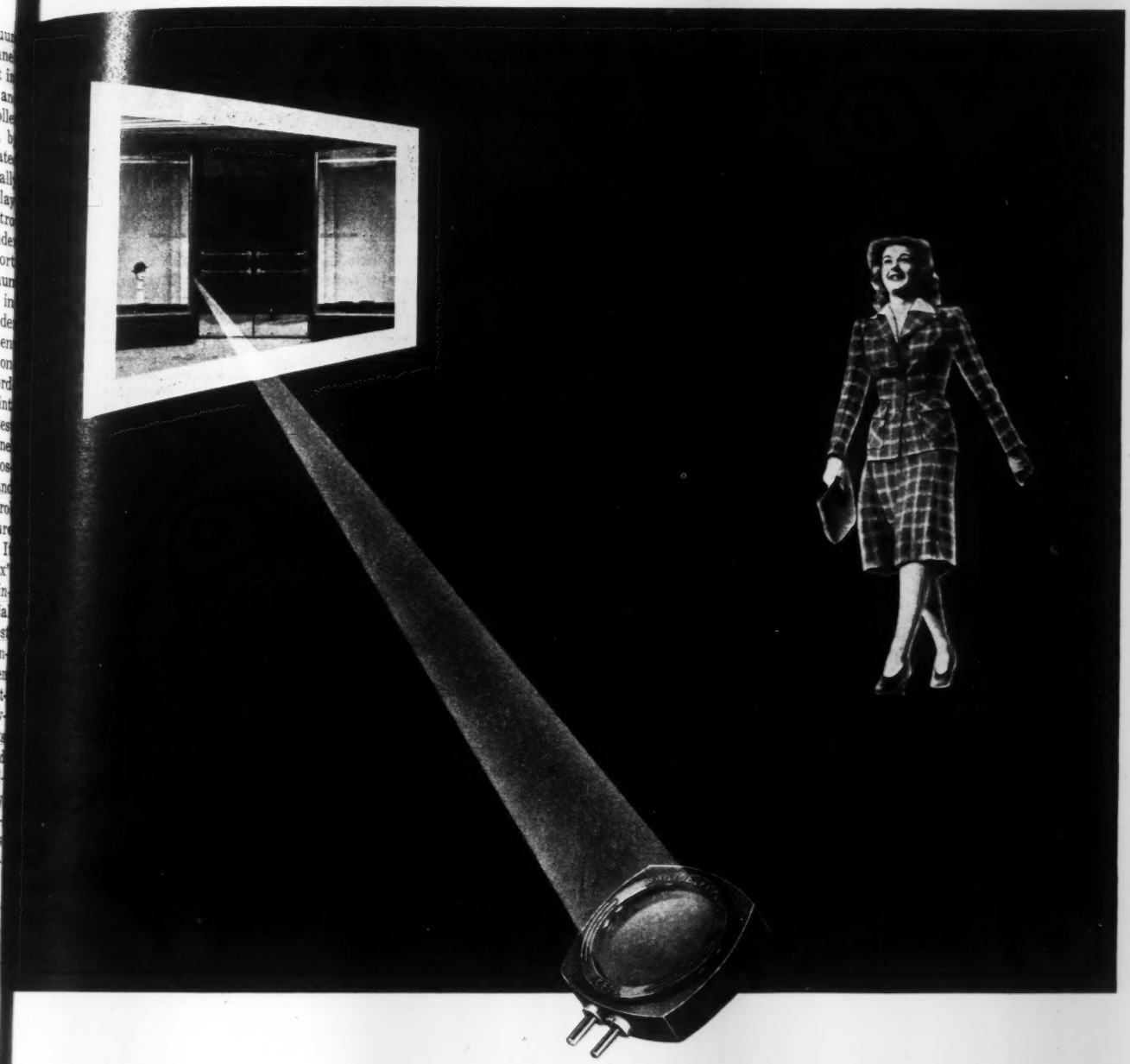
You can get complete information from Republic Drill & Tool Co., 322 S. Green St., Chicago 7, Ill.



Shankless Drill and "Drill Driver"

Remember this wrapper

Z-78



How to beat a woman—TO A DOOR

One way to startle the lay public into awed pleasure is to show them a door opened by means of a photo*cell*.

The practical beauty of this stunt is that you can do it over and over again without failure, even where shattering vibrations exist as part of normal operating conditions. For the Luxtron* photo*cell* is really rugged.

Another advantage is that Luxtron photo*cells* convert light into electric energy for the direct operation of meters and meter relays without amplification. They are lightweight, too. They are a good way to beat competition to a customer.

If you have any control problem that has defied solution with a simple, durable piece of apparatus, perhaps Bradley can throw some light on it—and make that light do the work for you. Write for literature and samples.

*T. M. REG. U. S. PAT. OFF

Another "Coprox" Rectifier

This center tap, full wave rectifier for high frequency current is one of a useful group of copper oxide rectifiers developed by Bradley. Illustrated "Coprox" bulletin mailed on request.

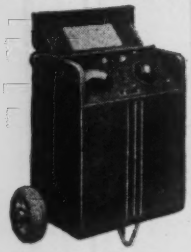
PHOTOCELLS—MASTERS OF LIGHT **BRADLEY** ***MASTER OF PHOTOCELLS***

BRADLEY LABORATORIES, INC., 82 MEADOW STREET, NEW HAVEN 10, CONNECTICUT

Vibrotest, for insulation resistance testing. Crankless. Many models.

Associated Research, Inc. Has the Answer

We show here only a few of the many instruments we manufacture for general and **particular** services. Simple, reliable and sturdy. We design and build for every requirement.

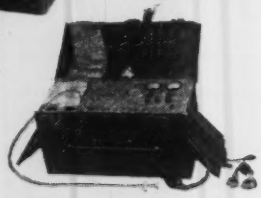


HYPOT—High voltage Insulation Breakdown Tester. Rubber Tired Wheels.

HAND TACHOMETER Measures r.p.m. and feet per minute.

VOLTAMMETER 8 ampere ranges 3 voltage ranges

VIBROGROUND Measures ground resistance.



Model 302 Keeler-Polygraph (Lie Detector) shown to right. Complete in one instrument.

DO YOU NEED RESEARCH OR DEVELOPMENT WORK?

Associated Research's specialists are always available. Complete mechanical and electrical facilities are at hand for design, development and manufacture for industry, institutions, laboratories and individuals.

Bring your electrical instrument problems to us.

ASSOCIATED RESEARCH, Incorporated

233 South Green St. Chicago 7, Ill.

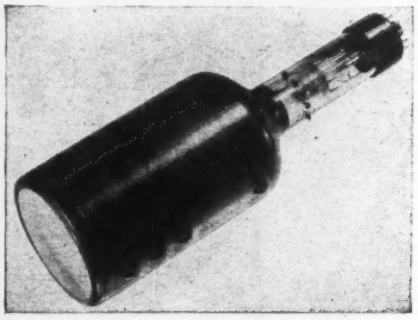
Engineering service representatives in all principal cities

The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

Multi-band Cathode-ray Tube for Ultra-rapid Writing Rates

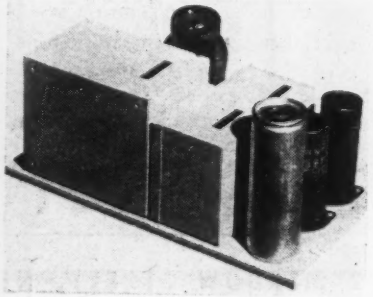
New "Type 5RP" multi-band cathode-ray tube with its 22,000 volts accelerating potential permits recording at writing rates in excess of 2500 km./sec. (using a 35-mm.



camera with an f:1.9 lens) corresponding to sine wave transients at 40 megacycles. New tube is of hot-cathode permanently-sealed high-vacuum type. Subdivision of intensifier element provides a controlled gradient allowing a total accelerating potential of 22,000 volts to be employed with only slightly reduced deflection sensitivity. Greatly increased brightness with small spot size results in a writing rate said to be "far greater than those heretofore obtainable." A cylindrical flat-face tube of the same approximate size as other 5" cathode-ray tubes, Type 5RP is constructed with deflection-plate leads brought out through the glass neck instead of the base. Shunt input capacitances and cross-coupling effects are minimized with this arrangement. Second anode and intensifier leads are brought out through the envelope to facilitate high-voltage operation.—*Allen B. Du Mont Laboratories, Inc., 2 Main Ave., Passaic, N. J.*

Rectifiers

New series of rectifiers is announced. "Type 201-A" is designed to furnish filament and plate currents to line amplifiers such as Langevin "102 Series," delivers 275 volts at 75 ma. and 6.3 volts at 8 amperes. Length $10\frac{5}{32}$", width $5\frac{7}{32}$", maximum height $6\frac{1}{2}$" ($5\frac{1}{2}$" above, 1" below mounting chassis), occupies one-third Langevin "Type 3-A" mounting frame. "Type 201-B" is similar to "201-A" except that an additional stage of filter is included. This unit is designed to supply filament and plate power to quiet pre-amplifiers, along with associated line amplifiers such as Langevin "102 Series." Both series are said to possess excellent regulation and low ripple content.—*The Langevin Company, Inc., 37 West 65th Street, New York 23, N. Y.*

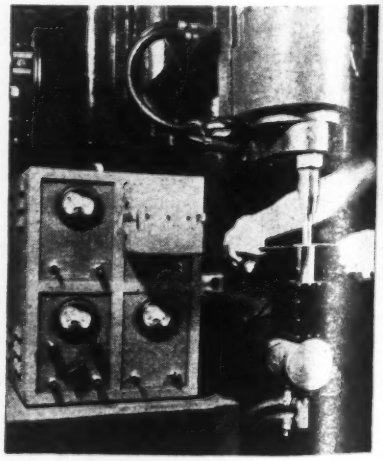


Fatigue-testing Machine

New small machine for testing plastics, plywood and lighter sheet metals with an alternating force capacity of 100 lbs. is said to be ideal also for testing structural components and machine parts in both repeated bending and repeated torsion; and is described as "truly a universal machine." Any predetermined alternating load can be kept automatically constant regardless of changes of deflection that may occur in specimen under test. Machine's 100 lb. capacity can be adjusted in increments of 0.2 lb. Speed is 1800 load cycles per minute. Maximum capacity in bending is 200 inch pounds; in torsion 1125 inch pounds. Machine will test plastics up to $\frac{1}{2}$" thickness, aluminum alloys of $\frac{3}{16}$", and steel of approx. $\frac{1}{8}$"; has ample space for testing bulky assemblies and it is adjusted easily for various specimen sizes. Numerous tapped holes and T-slots in the platens will accommodate special fixtures. Machine is seismically suspended in frame to eliminate vibration to floor.—*Southwark Division, Baldwin Locomotive Works, Philadelphia 42, Penna.*

Current-force Recorder for Welding Studies

New current-force recorder for recording current and force in resistance welding machine electrodes is for use in welding research and for periodic checking of welding machine performance. It is specially designed to be helpful to users of energy-storage type welding machines for determining when forge pressure is applied to



HOW WE SAVE 45 MINUTES OUT OF AN HOUR

When Connecticut Telephone & Electric Division began to make aircraft ignition terminals for a famous engine manufacturer, we knew that standard testing procedure could not keep pace with our mass production methods. Even a score of trained inspectors, each equipped with high-voltage testing equipment, would soon fall hopelessly behind.

Again Great American Industries engineers overcame a stubborn wartime bottleneck. They designed an electro-mechanical tester which accurately checks four parts faster than former methods could check one. Five such testers, operated by unskilled persons, have a capacity of 12,500 tests an hour . . . with a degree of error almost too small to measure.

This is but one of many new methods, contributed by G. A. I. engineering to speed the war effort. It will be equally important to efficient electrical manufacturing in time of peace.

HERE'S HOW IT'S DONE

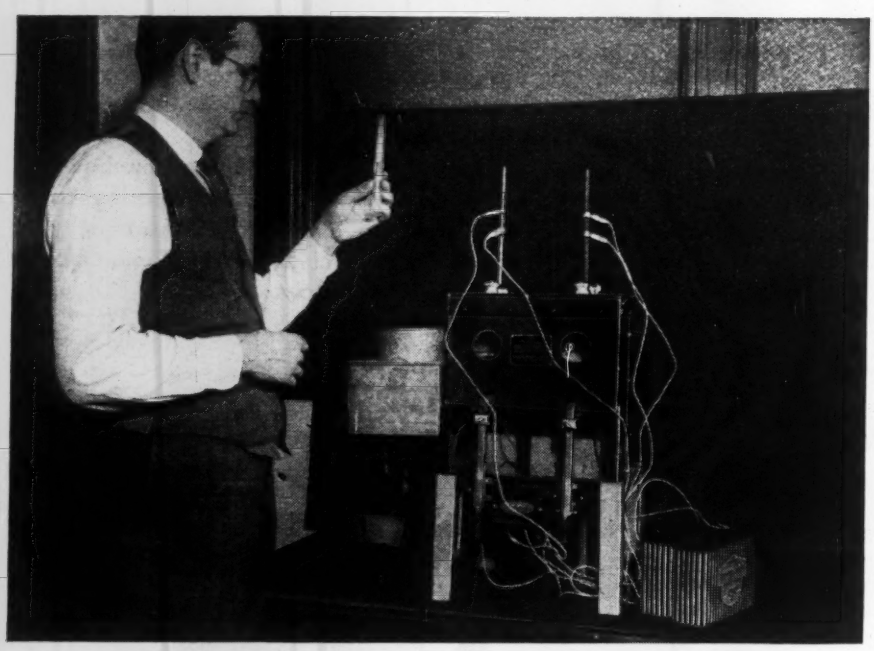
Operator places terminals to be tested in slots at edge of turntable. As each part reaches test point, one electrode of a 10,500 v. circuit contacts the conductor element of the terminal . . . while another encircles its insulating shell. Current leakage through minute cracks or porous sections of the insulation operates a relay which ejects the faulty piece. If the terminal meets specifications, it automatically falls into a chute and is conveyed to the packing bench. This swift, foolproof tester lends itself to many production tests of insulation.

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

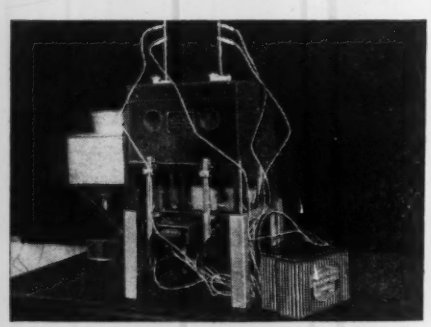
GREAT AMERICAN INDUSTRIES INC. • MERIDEN, CONNECTICUT

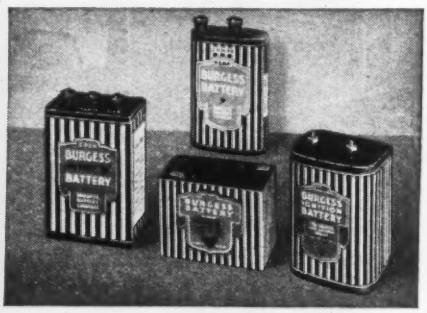
PORTABLE POWER PROBLEMS

THIS MONTH—BROWN-DUVEL MOISTURE METER



BURGESS INDUSTRIAL BATTERIES power the Brown-Duvel Moisture Tester, made by Seedburo Equipment Co., for the determination of moisture content in grain. And in thousands of similar industrial applications Burgess Batteries are providing the power for electronic test equipment. Purchasing agents and maintenance engineers know they can get a Burgess Battery for every need from their local Burgess distributor. For information on the *complete line* of dry batteries for all test and control instruments, write for the name and address of your nearest Burgess distributor.





ELECTRONIC ENGINEERS VOTED Burgess Industrial Batteries first choice in a recent nation-wide survey of dry battery preferences! If you need a special battery for a new instrument or a new application let Burgess engineers solve your problem with the correct battery type. *Burgess Battery Company, Freeport, Illinois.*

THE JOB AHEAD—JAPAN!

BURGESS BATTERIES

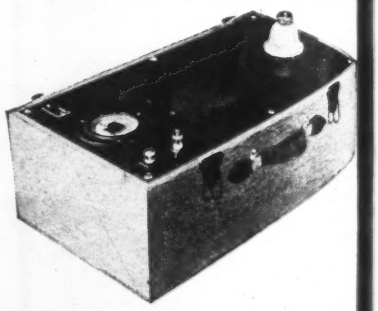
VOTED FIRST BY ENGINEERS
IN NATION-WIDE INDUSTRIAL BATTERY SURVEY

Recognized as the MOST COMPLETE LINE of dry batteries

the work with respect to the discharge welding current. In addition, new record permits resistance welding machine to comply with Navy Specifications, Navy PW-6A, Bureau of Aeronautics, Specifications for the Spot Welding of Aluminum Alloy, for Class A Spot Welding. New recorder consists of an amplifier-oscillograph unit and a special electrode holder. Amplifier-oscillograph unit, which operates from a 115-volt single-phase 60-cycle power source, is composed of a single-channel amplifier, an oscillator, a power unit, and a small magnetic oscillograph, all housed in a sturdy metal case. This unit simultaneously records a timing wave, the rapidly changing electrode force, and the electrode current of the welding machine while a weld is being made. Record also indicates squeeze time, duration and magnitude of welding current, rate of rise of forge pressure, and hold time. Special electrode holder is equipped with strain gages for measuring compressive strain, which is a measure of the force in the electrode, and a built-in shunt for diverting from the electrode a proportional amount of current, which is used to operate an oscillograph galvanometer. In operation, a 5000-cycle voltage from the oscillator is applied to two points in a strain gage bridge circuit, and output from two opposite points is a measure of force on electrode. Bridge output is fed into amplifier, which amplifies modulated carrier and rectifies and filters amplified output. Output is then fed to oscillograph, where record is made. Welding current and 60-cycle timing wave are recorded simultaneously on the 3½" strip chart.—*Specialty Products Division, General Electric Co., Schenectady, N. Y.*

Portable Kilovoltmeter

New No. 759 Portable Kilovoltmeter has 5 ranges that provide 1, 2, 5, 10 and 20 kilovolts d.c. at full scale. Accuracy of built-in indicator is ± 2%. Several



features have been incorporated including reversing switch which makes it unnecessary to change connections to terminals of Kilovoltmeter if polarity is reversed. Binding posts are available so that an external indicator may be used if full-scale accuracy better than 2% is required. Resistance multiplier section is carefully adjusted within 0.1% so that, if required, more accurate indicators may be used with the external connection. This also permits individual taps of multiplier to be used as accurate high-resistance standards. Instrument is mounted on an engraved Bakelite panel and is housed in a golden oak case 10⅛" × 10¼" × 10".—*Shallcross Mfg. Co., Collingdale, Pa.*

Battery Receptacle

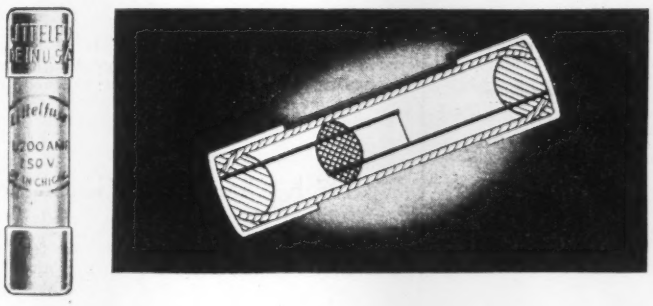
New three-contact battery receptacle conforming to Army-Navy Specification AN-2552 mates with any standard AN2551 plug and is adaptable to aircraft starting equipment and other uses. Four combinations are available: "AN2552-1," complete fitting with shield and three pin contacts; "AN2552-2," shieldless small pin contact; "AN2552-A1," panel without shield but having small pin contact; "AN2552-A2," panel without small pin contact. Contacts are brass with silver plate finish, and meet AN capacity requirements; one negative, one positive. La

First in Circuit Protection

Quicker than a Lightning Flash!

High-speed 8 AG Instrument Fuses are another Littelfuse first—the first to protect under ¼ amp. and, for over 18 years, a reliable protective fuse for safeguarding delicate instruments — galvanometers, microammeters, thermocouples, milliammeters, radio tubes, testers, rectifier tubes, etc.

The Littelfuse patented construction insures consistent high-speed action, opening circuit long before overload reaches dangerous magnitude.



These "quicker than a short circuit" Littelfuses are available in current ratings from 1/200 amp. to 2 amps. at 250 volts or less (1" x ¼" dia.)

Also available—wide selection of instrument fuse mountings and fuse extractor posts.

LITTELFUSE INCORPORATED
4757 N. Ravenswood Ave., Chicago 40, Illinois

Plants in Chicago and El Monte, California.

QUALITY IS BASIC

Today, our business continues to expand as satisfied customers voluntarily recommend our fuses to the manufacturers of airplanes, automobiles, radios and electronics equipment . . . and to the utilities and building industries, as well. The reputation which we won prior to the war, gave us the opportunity to design circuit protection devices for the Army, Navy and Air Forces. Early in the war, we were awarded the Army and Navy "E".

Throughout the years of progress, never have we lost sight of the basic fundamental on which our business was founded, namely: a quality of workmanship and materials which makes for precision in circuit protection and safety.

President

LITTELFUSE *Incorporated*

HIGHLY ACCURATE, STABLE VT VOLTMETER

features WAR RESTRICTED DEVELOPMENTS!

TELEVISO, pioneering in the production of measuring apparatus for the SONIC to UHF SPECTRUM, has specialized in building dependable Vacuum Tube Voltmeters.

A necessity wherever dependable voltage measurements within the range of 7 cps to 500 megacycles are required—the Televiso Series 200A VT Voltmeter is highly accurate and stable. IMPORTANT WAR TIME DEVELOPMENTS ARE AVAILABLE FOR THE FIRST TIME IN THE FOLLOWING FEATURES:

SUPERSENSITIVE RANGE—the lowest readable voltage is .05 volts on a maximum scale range of .5 volt.

FIVE VOLTAGE RANGES—.5, 2, 15, 50, 150—spread full scale on a 4½" meter dial for easy reading. Accuracy of readings are 2% full scale; middle scale accuracy is 5% or better.

PROBE CONSTRUCTION—detachable probe to eliminate cable wear; easily dismantled for tube replacement or for soldering to tube terminals for measurements in the 250-500 MC region; flat ½" wide brass terminals connect to input to make easy soldering to test or work piece; for low frequency work up to 100 MC, removable banana plugs are spaced ¾" center to center for use with standard jacks.

MECHANICAL CONSTRUCTION—of aluminum throughout; panel and cabinet are ¼" thick (cabinet is dural.); sub-chassis is ⅛" and spaced off the panel by studs to simplify servicing; all components are fastened to sub-chassis.

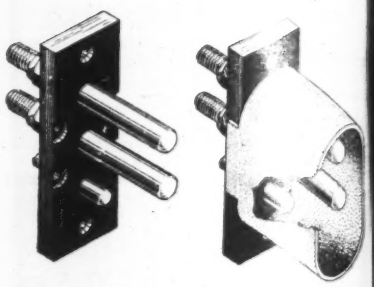
ELECTRICAL CONSTRUCTION AND CIRCUIT—Series 200A utilizes the finest components throughout and carries a two year guarantee. The circuit is a stable plate circuit rectifier. No diode input tube is used. The plate circuit rectifier type makes available higher input impedance at all frequencies. No shorting of input probe is required for zero adjustments. All zero adjustments are made once and remain constant. A panel adjuster is available to make the unit usable without heating up time. All filament and plate voltages are transformer and tube regulated.

BUILT-IN CALIBRATION VOLTAGE—All units have a jack which produces a constant 6.3 volts for standardizing. This is the regulated filament voltage. The sensitivity can be adjusted without tools in the event tubes are replaced in the field. The Series 200A will operate satisfactorily from any source of voltage from 95 to 130 volts a.c. Line voltage surges are not observable during use.

SIZE—14"H x 9½"W x 7½"D. Guaranteed 2 years. Price $170.00 F.O.B. Chicago

Televiso Products Inc.

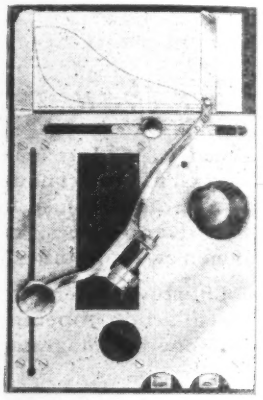
7466 IRVING PARK ROAD • CHICAGO 34, ILLINOIS



contacts are $\frac{7}{16}$" diam.; small contact $\frac{3}{8}$" diam. for indicator light. Receptacle panel is phenolic, drilled for two mounting holes. Shield is die-cast aluminum alloy with sand blast and clear lacquer finish. Four eyelets fasten shield to panel. — *Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif.*

Coffin Type Planimeter for M.I.P. Determination

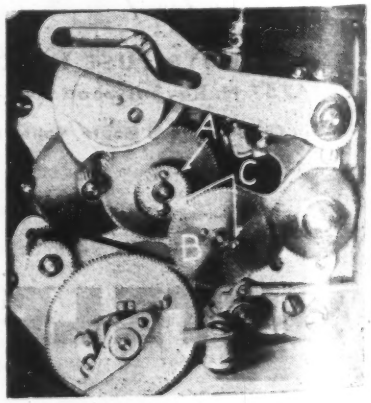
New streamlined Coffin type Planimeter for determination of mean indicated pressure from engine indicator diagrams, is simple to use, requires no technical training

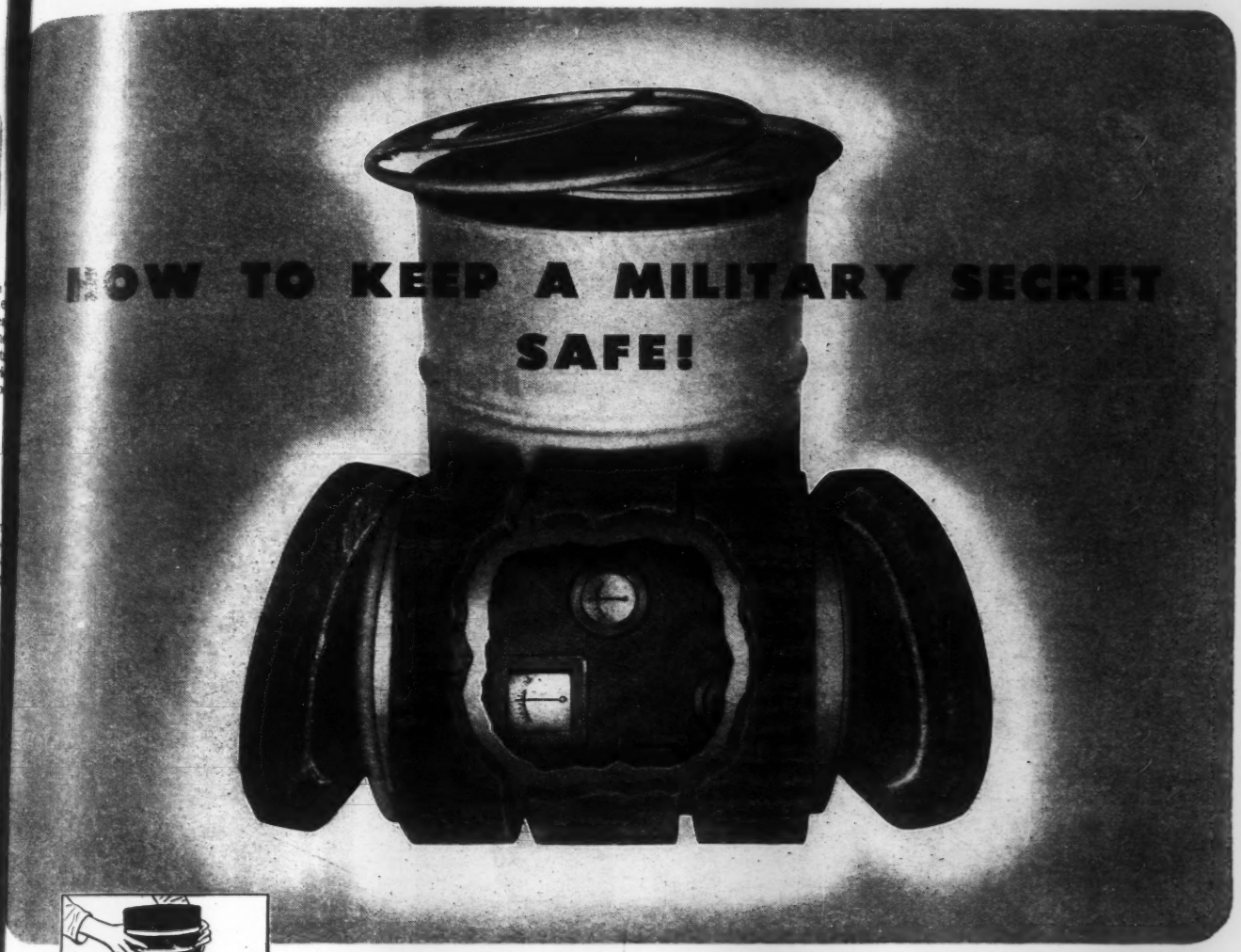


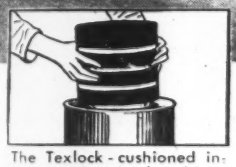
eliminates all calculating. It is furnished standard with commonly-used pressure scales, and instructions, in a sturdy compact case.—*The Trill Indicator Co., 7066 Bennett St., Pittsburgh 8, Penna.*

High Chart-speed Gearing for Recorders

New ranges of chart speeds for "Electronik Pyro-Potentiometers" are announced. Standard speed electronic recorders, single- or multiple-point models, incorporate gear changes for speeds of 5, 10, 15 and 20 inches per hour; fast speed electronic models, single- or multiple-point, will have internally mounted gears for speeds of 10, 20, 30 and 40 inches per hour. As shown in the ac

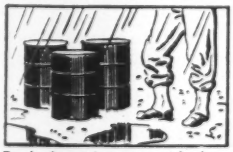






The Texlock - cushioned inner container is placed in a steel drum and the lid sealed with a Spongex* Gasket.

Safe and snug—it takes the shocks of transportation.



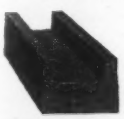
Texlock packaging with the sealed container resists all climatic conditions.

Many an intricate and fragile mechanism – secret and vital to military use – is now packaged and shipped to desert, jungle or arctic destination as matter-of-factly as any shipment of canned goods. Efficient, constant protection against shocks of travel and varying climatic hazards is assured by Texlock* – the modern, pre-tailored packaging material.

Texlock – rubberized hair or bonded fibre – is lastingly resilient. It is unaffected by moisture, heat or cold – will not become brittle, bunch up or shift about. It can be pre-tailored to closely cradle any shape, size or weight of article and to fit into any case, carton or container. It may be used repeatedly for shipping new, or returning worn or damaged parts or assemblies.

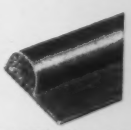
The idea illustrated here – plus a host of other Texlock uses for cushioning, packing and space-filling—may be the answer to your packaging problems, wartime or peacetime, domestic or export. Write for samples, describing your specific problem. Sponge Rubber Products Co., 236 Derby Place, Shelton, Conn. Plants in Derby and Shelton, Conn. Sales Offices: New York, Chicago, Washington, Detroit.

*Trade Mark Reg. U. S. Pat. Off.



Full and half-round cord or tubing and molded strips in various shapes for any sealing or gasketing job.

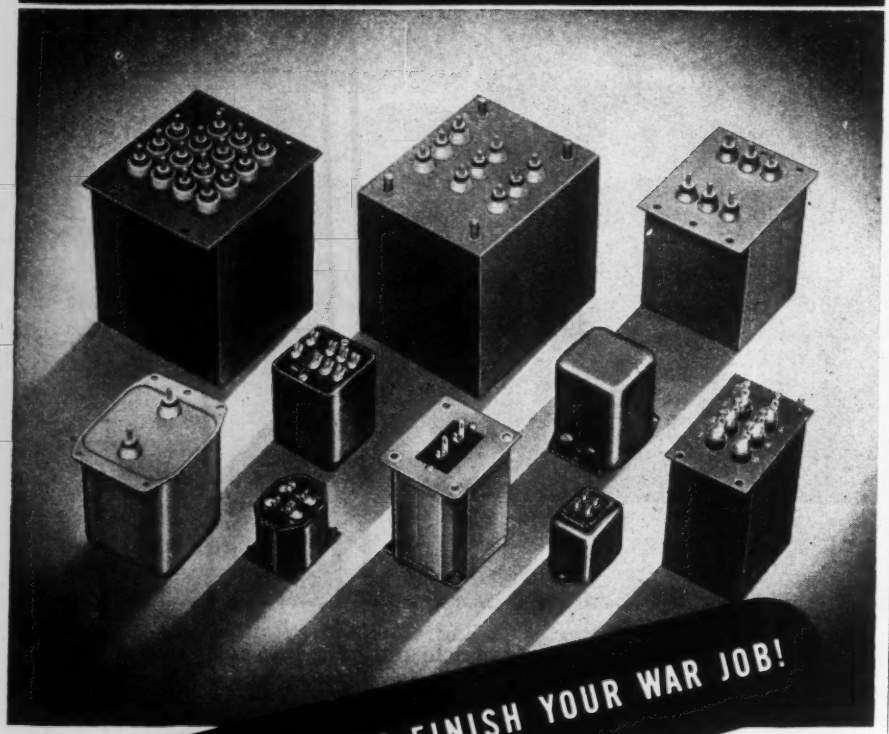
Spongex is a resilient, flexible, blown form of rubber available in soft, medium and firm densities.



SPONGE RUBBER PRODUCTS CO.

WORLD'S LARGEST MANUFACTURER OF CELLULAR RUBBER AND BONDED FIBRE PRODUCTS

Production AVAILABLE on special design transformers



LET STANCOR HELP FINISH YOUR WAR JOB!

A limited schedule can be accommodated now for designing and manufacturing special transformers to your specifications. The same facilities and personnel which put Stancor in the front rank of war auxiliary producers — are still on the job and are your guarantee of top-flight engineering and production experience. Write enclosing specifications, or wire.

Incidentally that's a good thing to remember too for your future needs. Expert planning, modern equipment, precision winding machinery, special samples division with competent sales engineers—all will represent the highest efficiency in satisfying your most exacting transformer requirements.

STANCOR

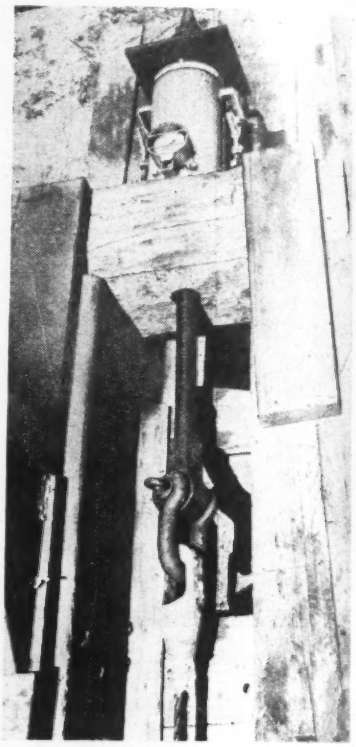
STANDARD TRANSFORMER CORPORATION

1500 N. HALSTED STREET • CHICAGO 22, ILLINOIS

companying illustration, the gears are changed by removing screw C from gear A and B and by lifting the gears from the assembly. The new speed gears are then installed and screw C is replaced.—*Brown Instrument Co., 4482 Wayne Ave., Philadelphia 44, Penna.*

Equipment for Tensile Tests in Field

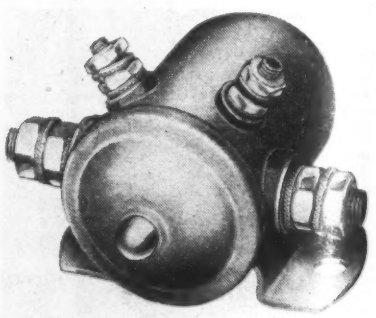
Newly-developed application of "Simplex" Jenny Center Hole Hydraulic Puller" in tensile testing. Illustration shows a "Model 10010 Simplex Jenny," of 100-tons capacity



testing a 1½" cable sling to 90,000 lbs. A clevis through the dead eye is secured to a long bolt which has been inserted through the Jenny and fastened above the cylindrical ram. Tension is continuously indicated on dial. Available in five models of 30-ton to 100-ton capacity, the Jenny is well adapted for making tensile tests of cable, rods, hooks, etc. Most tests can be made by one man.—*Templeton, Kenly & Co., 1020 S. Central Ave., Chicago 44, Ill.*

D-c. Solenoid Contactor

New "Type 71" direct-current solenoid contactor is a sturdy, compact unit for low-voltage power application on either stationary or mobile apparatus. Magnet coil and contacts are fully enclosed in a magnetic iron case, with cap spun over, to provide complete protection against dirt, moisture, vermin, and other destructive agents.



metal parts are plated for further protection. This contactor is available with single-pole normally-open double-break contacts, rated at 100 amperes continuous; 300 amperes in-rush at 32 volts d.c. and below. Continuous duty magnet coil with insulated coil terminals. Copper contacts are standard, though special alloys are available. Approximate size of unit, width 3¼", depth 3", height 2½". Average weight, 14 ounces. Although not designed for Air Corps specifications, it will pass 10 *G* vibration or acceleration tests and withstand vibration and shocks normally encountered in passenger cars and trucks.—*R-B-M Mfg. Co. (Div. of Essex Wire Corp.), Logansport, Indiana.*

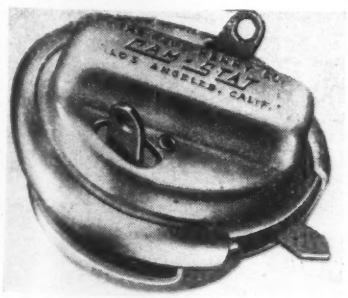
Pneumatic Diaphragm Motor

New "Model V" Diaphragm Motor is specially designed for use in conjunction with throttling type pneumatic control instruments to operate rotary stem valves

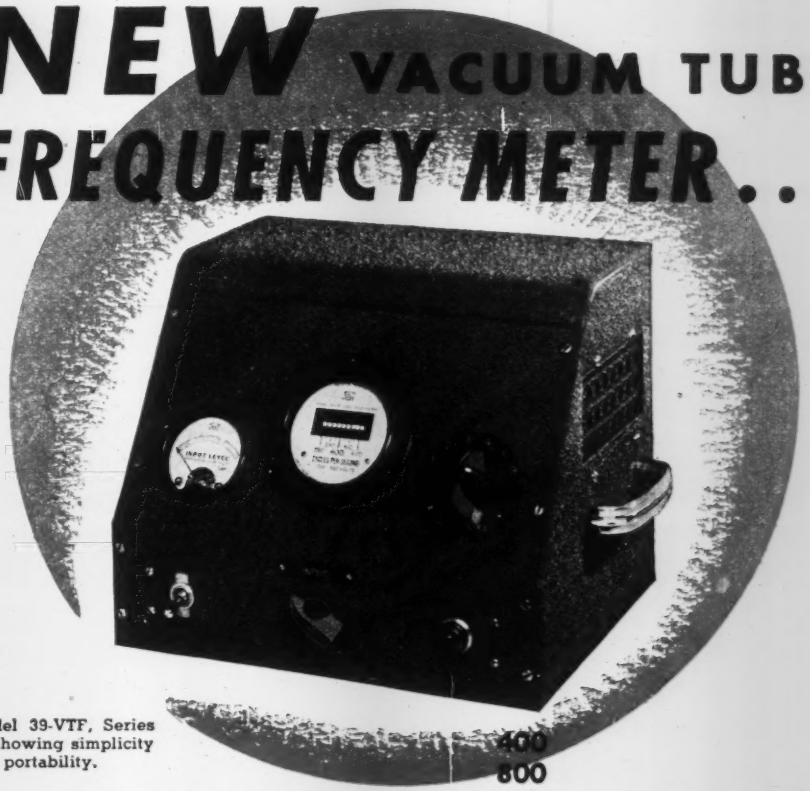
similar mechanisms. Its novelty lies in the use of an outboard type of lever connection to the valve, permitting mounting the motor directly over valve body rather than eccentrically. It is unusually compact, has a low center of gravity and, when used with a pneumatic valve positioner, is powerful enough to operate valves up to 8" in size. Operating lever can be clamped in any position of the lower 200° arc and, if desired, an additional lever can be attached to other end of shaft.—*Conoflow Corporation, 2100 Arch St., Philadelphia 3, Penna.*

Automatic-control Switches

New "Cam-Stat" line of control devices is said to be complete and to embody a unique snap action arrangement which lends itself to unusually accurate control of temperature, pressure, humidity and mechanical displacement. Other features are double-break contacts; applicable range from −100°F. to +600°F.; enclosed contacts; s-p.s-t., s-p.d-t., or independent circuit d-t.; resistant to vibration; low thermal lag; tamper proof; adaptable to any mounting means; contact openings from .010" to 0.060", as desired; operating parts always in balance thermally as well as geometrically; accuracy of calibration not affected by under-heat or over-heat condi-



NEW VACUUM TUBE FREQUENCY METER...



Model 39-VTF, Series A, showing simplicity and portability.

...FOR FREQUENCIES IN 400 800 1200 1600 2400 3600 CYCLE BANDS

MODEL 39-VTF, Series A, a new development of J-B-T engineers, measures frequencies in six specific bands with accuracy of ± 0.25% of the frequency being measured, and with sufficient amplitude to be easily read.

Vacuum tube multivibrator circuits divide the incoming frequency by 1, 2, 3, 4, 6 or 9, depending on the position of the multiplier switch, and show the result on the time-tested, standard 400 cycle meter.

Regular line current is used for power supply, permitting an input sensitivity of 500,000 ohms. Response is not affected by irregular wave form, nor by harmonic content of unknown frequencies of less than 10% or 15% . . . and input control permits use from 100 to 350 volts.

The result is an instrument of high accuracy and high stability with permanent calibration . . . especially useful for checking audio oscillators, frequency converters, radar equipment, and for standardizing less accurate frequency measuring units.

Check These Points

- EXTREME ACCURACY ... within ± 0.25% of frequency being measured.
- PERMANENT ACCURACY . . . no further calibration or standardization required at any time.
- STABILITY... no temperature drift after initial 30 second warm-up.
- BURN-OUT PROOF . . . no protection needed against accidental above-range frequencies.
- SENSITIVITY . . . 500,000 ohms.
- SIMPLICITY... uses standard tubes.
- POSITIVE SWITCHING... built-in switch is J-B-T's own rugged, coin-silver plated instrument switch, as supplied for high quality testers.

New Booklet . . . just off press, illustrates other types of J-B-T Vibrating Reed Frequency Meters. Ask for Bulletin VF-43-1C.

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J-B-T INSTRUMENTS, INC.

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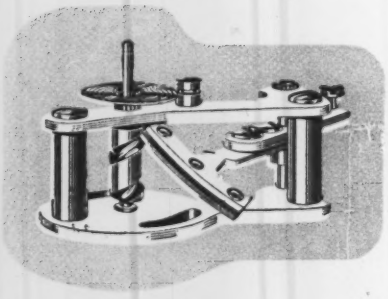

The groove in the roller of the Helicoid movement has a helicoid surface. This surface is hard and polished. The Bakelite cam rides on this surface in continuous, rolling point contact. No metal spur gear teeth can compare with this combination in wear resistance, smoothness and accuracy.

The principle of the helicoid is as old as Archimedes. But its use to translate and multiply linear motion into rotary motion in the same plane is new in the Helicoid movement. And the Helicoid movement is the first new, major improvement in pressure gauges since the Bourdon tube was invented.

Only Certified Pressure Gauges are made with the Helicoid movement. They are guaranteed to test-gauge accuracy. Yet, they will wear longer and remain accurate longer than any other pressure gauge made. They are ideal for engines, locomotives, turbines, tractors, hydraulic presses, pumps, and compressors.

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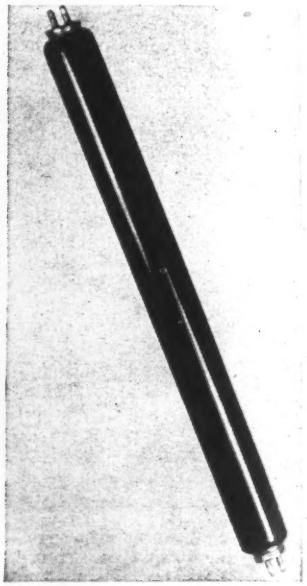
tions. "Cam-Stat" temperat... controls ar... fully adjustable over a "w... range" ar... are furnished with operat... differential... running down to as low as ...F. They ar... "small, light, rugged, effi... t and ca... handle substantial loads." ...llustrated ... "Model C" thermostat weig... less tha... one ounce and rated at 10 a... 115 volt... a.c. or 28 volts d.c. Other mo...ls of "Cam-Stat" thermostats can be su...lied to su... any thermal control problem...—*The Pu... Henry Co., Thermal Division, ...7 South L... Cienega Blvd., Los Angeles 3...alif.*

Near-ultraviolet Lamps

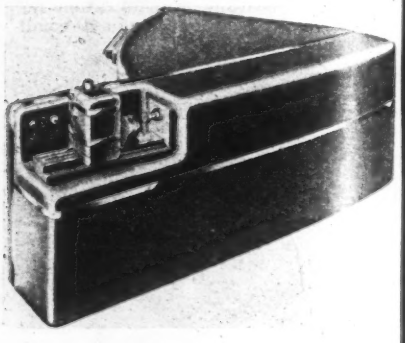
New "Vio-Ray" line of "...ack Ligh... Lamps," said to provide nea...ultraviolet radiation in the region of 365... Angstrom Units, is announced. According to manu...



facturer, new light source is Mazda fluorescent lamp to which is processed the special "Vio-Ray" plastic filter that absorbs unwanted visible light, yet permits the passage of near-ultraviolet light. New lamps operate with standard fluorescent equipment, and are said to provide an efficient source of near-uv. radiation for all applications requiring excitation of fluorescent pigments and materials.—*Vio-Ray Mfg. Co., 5022 N. Kedzie Ave., Chicago 25, Illinois.*

Two-meter Spectrograph

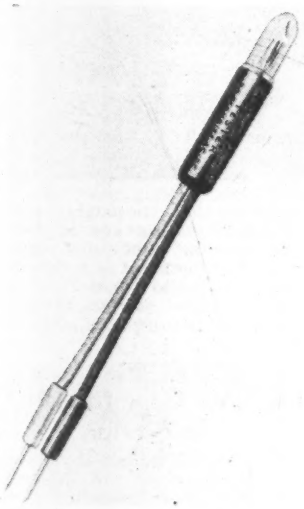
New two-meter grating spectrograph is designed for analysis of highly alloyed ferrous metals and other materials containing complex spectra, as well as for general research work. Capable of identifying 72 elements, new Spectrograph may be used for identification, sorting and miscellaneous or research applications, as well as routine or research quantitative analysis. A high dispersion yet compact instrument was achieved through use of super-fine gratings. Two kinds of original gratings are available: One has 36,600 lines per inch, or 91,500 total lines, produces a dispersion of



40 A.U. per mm. in the first order and 1.70 A.U. in the second order; spectrum available for photography in first order is 2100-3000A and 1650-3500 in second order. The second grating has 24,400 lines per inch, totaling 61,000 lines: dispersion of 5.2 A.U. per mm. in the first order and 2.6 A.U. per mm. in the second order; spectrum that may be covered in first order is 1850 to 4200 and 1850 to 4500 in second order. New spectrograph can be supplied with either of these two gratings. Both may be furnished, which either may be brought into use by a small angular shift of incident beam from one grating to the other. A 24" movable camera, providing a 20" spectrogram on a 35-mm. spectrum film, is movable on a radius arm allowing instantaneous photograph in regions from 1850-9200 A.U. This makes a versatile operating unit: positioning along the Rowland circle so that any 20" portion of total 60" spectrum may be photographed at one time. Two cameras may also be supplied for simultaneous photography of 40" of the spectrum. Eighteen spectra can be photographed on a single strip of film. Controls and camera are located at one end of instrument. A single control panel governs shutter timing, camera and aperture racking and grating door opening. Instrument is so constructed that it is possible to enclose camera side in a darkroom. Outside dimensions, 9"×6'6"—*A. R. L. Dietert, Glendale, Calif., and 9330 Roselawn Ave., Detroit, Mich.*

Pocket Circuit Tester

New "All-Purpose Circuit Tester" for all who have to do with electricity, is convenient vest-pocket type, and indicates voltages from 90 d.c. and 60 a.c., to 500 volts a.c. or



d.c. A General Electric neon lamp on the top glows in varying intensities indicating circuit conditions. No glow indicates a dead line. The lamp lights on currents as low as one microampere. — *Amerline, 1753 North Honore St., Chicago 22, Illinois.*

Soil Tester

New "Solu-Bridge Soil Tester," built specifically for soil workers, was designed in consultation with the Agronomy departments of several State Agricultural Colleges to fill the growing need of soil workers and greenhousemen for a practical instrument to measure the electrical conductivity of soil extracts, particularly greenhouse soils. It is a self-contained sturdy, low-cost, easy-to-operate a-c. Wheatstone bridge, employing a cathode-ray "eye" tube to indicate point of balance, and operating directly from 115-volt 60-cycle power line. A temperature compensator is incorporated to eliminate need for computation. Range is from 10 to 1000 mhos $\times 10^{-5}$ specific conductance, corrected

HICKOK

Water Proof, Moisture Proof *and* Steam Proof METERS

Built in accordance with the War Standards Drawings
D.C. MILLIAMMETER
AVAILABLE IN 2½"—3½"—4¼" ROUND STYLES
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VOLTMETERS . . . AMMETERS . . . MILLIAMMETERS . . . MICROAMMETERS . . . WATTMETERS . . . BOTH AC AND DC

Now, you can get HICKOK precision and dependability in a new line of hermetically sealed meters. Available in 2½", 3½" and 4¼" round styles. Dimensions of American War Standards Assn. Drawings C39.2-1 and C39.2-2. The 4¼" size is built especially for use in radio service equipment where several scale arcs are required.

All instruments are hermetically sealed and both vacuum and pressure tested under water. Case fabricated of pressed steel and made corrosion resistant to meet specifications. Terminals are a special glass soldered-in type.

All meters are fully shielded, permitting use on either magnetic or non-magnetic panels. Operation is accurate and dependable even up to 85° centigrade. Internal pivot construction in D.C. types assures longer life and greater resistance to shock and vibration. Write for further information today.

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Cost of Special Bearings was Jobber's Nightmare

Air Express solves his problem — for 5% of selling price!

Maybe *your* business isn't like this. Maybe it is. A lot of them are. Anyway, here's this jobber's story:

He stocks a standard line of precision bearings—a big investment. If he had to carry *all* special types and sizes, his investment would run into a nightmare of high-cost slow-turn "specials."

So in order to give 100% service, what does he do? Simply this. When a customer wants a "special", the jobber wires the manufacturer and has the order shipped Air Express. Same-day delivery is often made on orders placed early in day.

Cost of Air Express? Only 5% of his selling price — and on goods he doesn't have to carry!

Specify Air Express-a Good Business Buy

The inventory of any supplier in the nation is within a matter of hours of your business when you specify this fastest delivery service.

Shipments travel at a speed of three miles a minute between principal U. S. towns and cities, with cost including special pick-up and delivery. Same-day delivery between many airport towns and cities. Rapid air-rail service to 23,000 off-airline points in the United States. Direct service to scores of foreign countries.

AIR MILES	2 lbs.	5 lbs.	10 lbs.	25 lbs.
250	$1.04	$1.25	$1.57	$2.63
500	$1.11	$1.52	$2.19	$4.38
1000	$1.26	$2.19	$3.74	$8.75
2500	$1.68	$4.20	$8.40	$21.00

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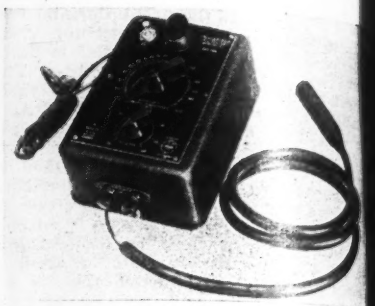
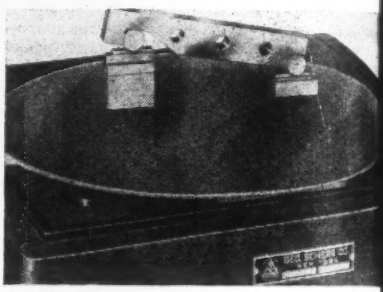


to 25°C. To make a measurement, a sample of air-dry soil is mixed with twice its weight of soft water, shaken for a minute or two, and the coarse particles allowed to settle for a few minutes. Solution is then poured into a clean vessel, its temperature checked with a thermometer, and temperature compensator is set to that value. Conductivity cell is dipped into the extract and main dial turned until "eye" shows balance, whereupon the specific conductance is read directly from the scale. No calculations are necessary.—*Industrial Instruments, Inc., Pollock Avenue, Jersey City 5, N. J.*

Sine Bar

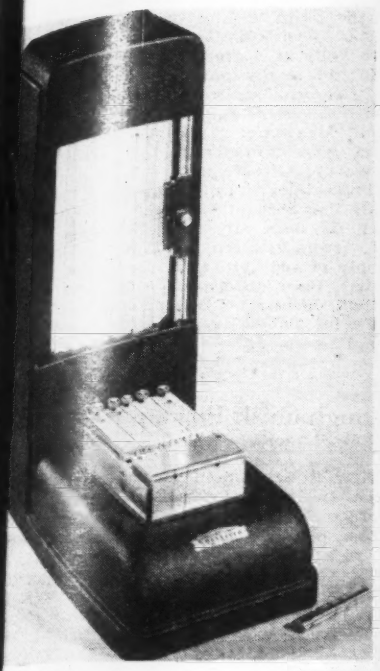
New sine bar is announced in four models. It comes in the following sizes: 1″×⅝″×5″ and 1″×1¼″×5″. Both sizes are available in ground surfaces and in lapped



surfaces. Bars are thoroughly normalized by both heat treating and by being subjected to freezing processing temperatures below −100°. Illustrated is Scherr Sine Bar on optically polished "Opti-Flat," the new Pyrex brand glass surface plate.—*George Scherr Co., 200 Lafayette St., New York 13, N. Y.*

5-tube Air Gage for 10-point Inspection

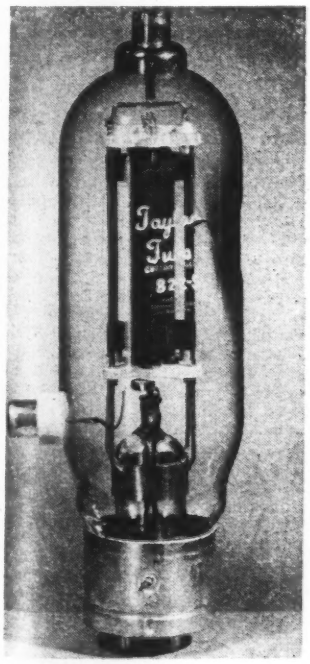
New high-amplification 5-tube "Precisionaire" is announced as "an outstanding example of the almost unlimited possibilities of air gaging." Five tubes, each capable of providing an amplification of 18,000 to 20,000 to 1, are combined in one instrument to check ten points along the cylindrical surface (½" diam. in illustration) of the part being inspected. Tolerance at each point is ±5 microinches. Out-of-roundness, taper and undersize or oversize conditions are disclosed. The part is checked as shown by placing it against the left side rail and rotating it through 180°, this operation simultaneously checking five points. It is then placed against the right side rail and again rotated through 180°, which gives a simultaneous check of five other points. Tungsten carbide locating pads at bottom and both sides of gaging slot serve to properly locate the masters and work part. Minimum and maximum fixed size masters are used to set up "Precisionaire." Center line on transparent slide is used as reference for this setting. With maximum size master in gaging position, orifices and air pressure in each tube are so regulated that all five floats are at the same horizontal line; the same method is used in setting minimum



ster. Maximum and minimum tolerance nits are indicated by lines on the transrent adjustable sight. This sight, in conction with calibrated scale, enables opator not only to reject defective parts but classify acceptable parts as desired.—*effield Corp., Dayton 1, Ohio.*

High-power Triode

New high-power "822-S" triode with a equency application limitation of 30 Mc, designed for peak performance in all RF rvices, diathermy and Class B audio, is able also in induction heating applicaons. It will furnish up to 1 kw. of audio tput in Class B (in pairs) at 3000 volts d 0.5 amp. on the plates or as low as 400 atts audio in Class B with 1500 volts at 390 amp. As a Class C amplifier (telephone) its maximum ratings include a ower output of 405 watts with 2000 volts 0.250 amp. on the plate and 13.7 watts iving power. Under typical Class C elegraphy) ratings new tube will provide



HERMETICALLY-SEALED RESISTORS

JUST OUT!

This new Shallcross Engineering Bulletin "R" gives full details on Shallcross Akra-Ohm Resistors including styles designed to meet Accurate Fixed Wire Wound Resistor Specifications JAN R93.

- Resistance element entirely sealed.
- No separate lead from resistance element to terminal.
- *Standard* terminal and mounting arrangements.
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- *Both* resistance form and protective shell are ceramic.
- Resistance element, winding form, and protective shell form one rigid unit.
- Rugged, rigid construction allows rough handling without danger of breaking seal.
- Resistances from 1000 ohms to 10 megohms non-inductively wound can be hermetically sealed without difficulties due to leakage.
- Low tolerances, 1% or less, are standard.

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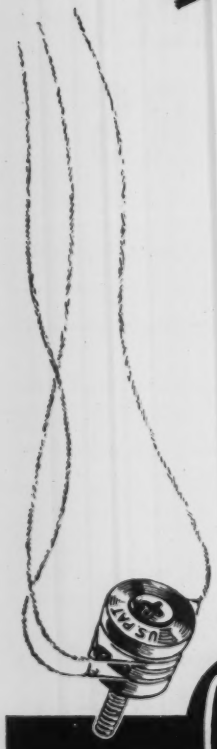

Here is a brand-new development by Conant to meet the demand for applications involving the balanced bridge principle in AC operation.

Example: The conversion of standard Wheatstone bridge instruments to AC. In such applications, the AC accuracy and performance are equivalent to DC operation on the same instrument. Null indication is not affected by temperature, frequency, wave form or line voltage fluctuations.

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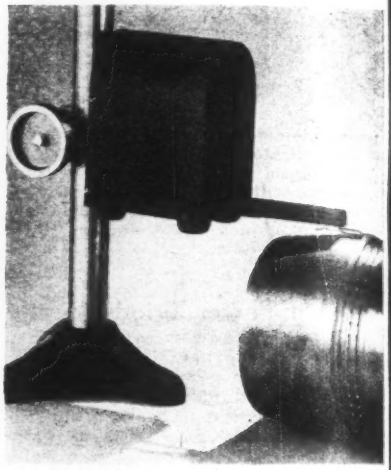
1526 Ivy St., Denver, Colo.
4214 Country Club Dr., Long Beach 7, Cal.
Export Div., 89 Broad St., N. Y. 4, N. Y.
50 Yarmouth Rd., Toronto, Canada

600 watts output with 2500 [illegible] is at 0.3 amp[illegible] on the plate with a drivi[illegible] power of 1[illegible] watts. *Electrical characteri[illegible]*s: Filamen[illegible] —10 volts at 4 amps.; Amp[illegible]ication facto[illegible] —30; Plate dissipation—20[illegible]atts; Inte[illegible] electrode capacitances: grid-p[illegible]: 13.5 mm[illegible] grid-filament: 8.5 mmf, pla[illegible]ament: 2[illegible] mmf; Maximum overall len[illegible]—9"; Maxi[illegible] mum glass diameter 2⅝"; [illegible]—Standar[illegible] 50-watt; Glass-Nonex: T[illegible]l rating[illegible] (Class C telegraphy): Plate d[illegible]volts—250[illegible] Plate d.c. current—300 ma.; [illegible]d d.c. cur[illegible] rent—51 ma.; Grid bias d.c[illegible]lts—minu[illegible] 190, (from grid leak of 3730 [illegible]s or fixed[illegible] supply of 100 volts plus a gri[illegible]eak of 176[illegible] ohms), Plate dissipation—150 [illegible]tts; Powe[illegible] output—600 watts; Driving pow[illegible]—17 watt[illegible] —*Taylor Tubes, Inc., 2312 W[illegible]nsia Ave[illegible]nue, Chicago, Illinois.*

Rough-finish Pick-up for Surface Analyzer

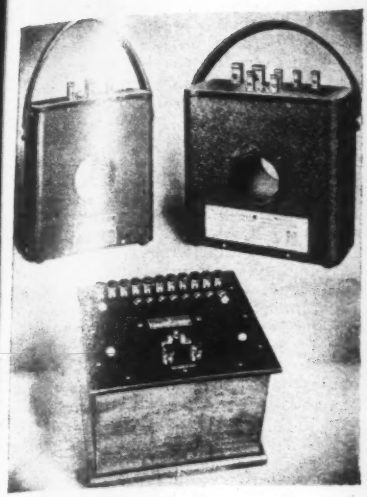
New Rough-Finish Measuring Head wi[illegible] meet the need for checking the roughe[illegible] surface finishes and waviness in metal[illegible] glass, plastics, plated and painted mat[illegible]



rials. Owing to trend towards more rig[illegible] specifications and tolerances, particularly o[illegible] turned surfaces, new Routh-Surface An[illegible] alyzer is said to make a perfect complemen[illegible] for the original Brush Surface Analyzer[illegible] New Pickup and Drive Head accurately[illegible] measures irregularities from 100 to 3,00[illegible] microinches, peak to valley. It thus extends[illegible] use and range of Brush Surface Analyze[illegible] from 1 to 3,000 microinches. *Brush Develop[illegible]ment Co.*, 3331 *Perkins Ave., Cleveland[illegible] Ohio.*

Portable Current Transformers

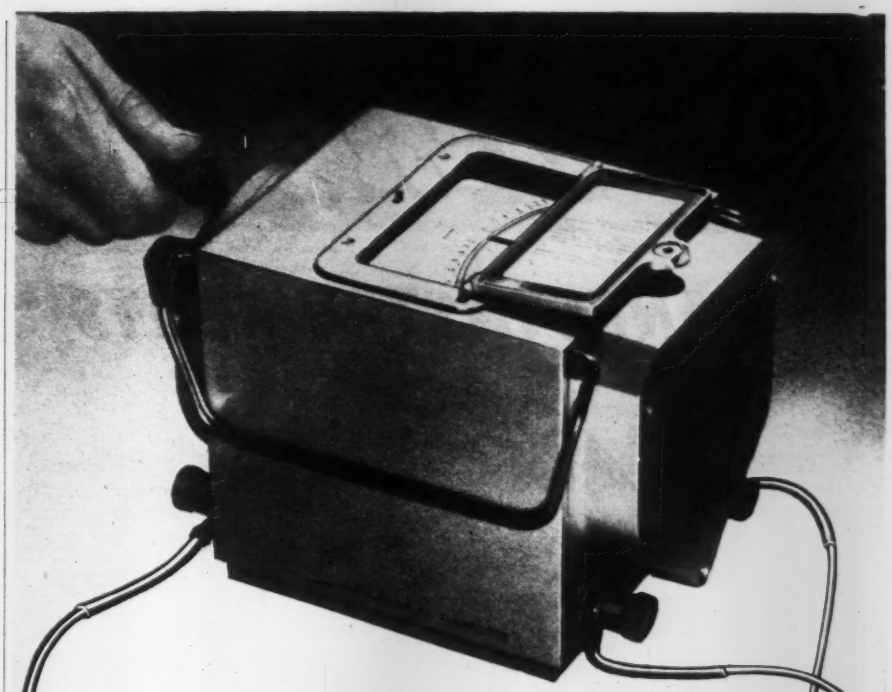
New "Types JP-2, -3 and -4" portable[illegible] current transformers are highly accurate[illegible] and may be obtained as multirange units[illegible] "Type JP-2" is also available as a single[illegible] range unit. "JP-2 and -3" meet accuracy re[illegible] quirements of ASA 0.3 accuracy class with[illegible] burdens B-0.1, -0.2, and -0.5 at 60 cycles[illegible] Both units, of through-window-type con[illegible] struction, are suitable for laboratory-standard[illegible] ard work or for field tests. "JP-2" is not[illegible] supplied with a primary winding, but there[illegible] is a hole in the core through which a cable[illegible] or conductor can be passed. However, there[illegible] is a tapped secondary winding, and term[illegible] nals on top of case are all secondary terminals. "JP-3" is designed with a combination of wound-primary and through-primary con[illegible] struction. Ratings of 100 amperes and below are obtained by a wound-primary with terminals on top of transformer. By passing a conductor through transformer window once, 1000- and 1200-amp. ratings may be obtained. Additional ratings may be obtained in both units by passing the conductor through the window two or more times. Both "JP-2 and -3" units are insulated for use



on circuits not exceeding 2500 volts, but an be used over cables on higher voltage ircuits, provided the cable is insulated for he circuit voltage. Cases are aluminum ith durable black crystal-line-lacquer fin-sh; top of cases black compound; leather arrying handle is provided. "Type JP-4" ransformer is designed for highest-grade pplication as a laboratory standard. It is f wound-primary construction with taps in rimary coil for different ratios. Each pri-ary coil (0.25 to 15 inclusive) is protected y a removable fuse. Secondary terminals re provided with a short-circuiting switch, nd also with a Thyrite protector to guard gainst accidental opening of secondary cir-uit. Unit is enclosed in a walnut-finished ooden case; top of transformer is black ompound and all terminals are mounted on op.—*Meter & Instrument Div., General Electric Co., Schenectady 5, N. Y.*

Vacuum-tube Voltmeter

New "Series 200A" vacuum-tube volt-meter is for voltage measurements within the range of 7 c.p.s. to 500 Mc. Features: (1) Lowest readable voltage is 0.05 volts on a maximum scale range of 0.5 volt. (2) Five Voltage Ranges: 0.5, 2, 15, 50, 150, spread full scale on a 4½" scale for easy reading. (3) Accuracy, 2% full scale; mid-dle scale accuracy is 5% or better. (4) Detachable probe to eliminate cable wear; easily dismantled for tube replacement or for soldering to tube terminals for measure-ments in the 250-500 Mc. region; flat ½" wide brass terminals connect to input to



"MEGGER"*
GROUND TESTER

The "Megger" Ground Tester measures resistance to earth of ground connections, quickly, easily and accurately. Simply connect the instrument to the installed ground and to two reference grounds. turn the crank and read resistance directly on the scale. Unaffected by polarization, electrolysis. stray earth currents or by the exact location or resistance of the auxiliary ground connections. Ranges from 0-3 ohms to 0-30,000 ohms.

"Megger" Ground Testers are invaluable for determining the nature of ground connections, and whether they are in condition to perform the serv-ice for which they are designed and installed. During the past 15 years these instruments have become standard equipment among many power companies, railroads, telegraph and telephone companies and industrial plants throughout the U. S. A. They are as rugged, reliable and simple in operation for ground resistance measurements as are our "Megger" instruments for testing insulation.

Write for illustrated Technical Bulletin on Ground Resistance Testers No. 1285- I.

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